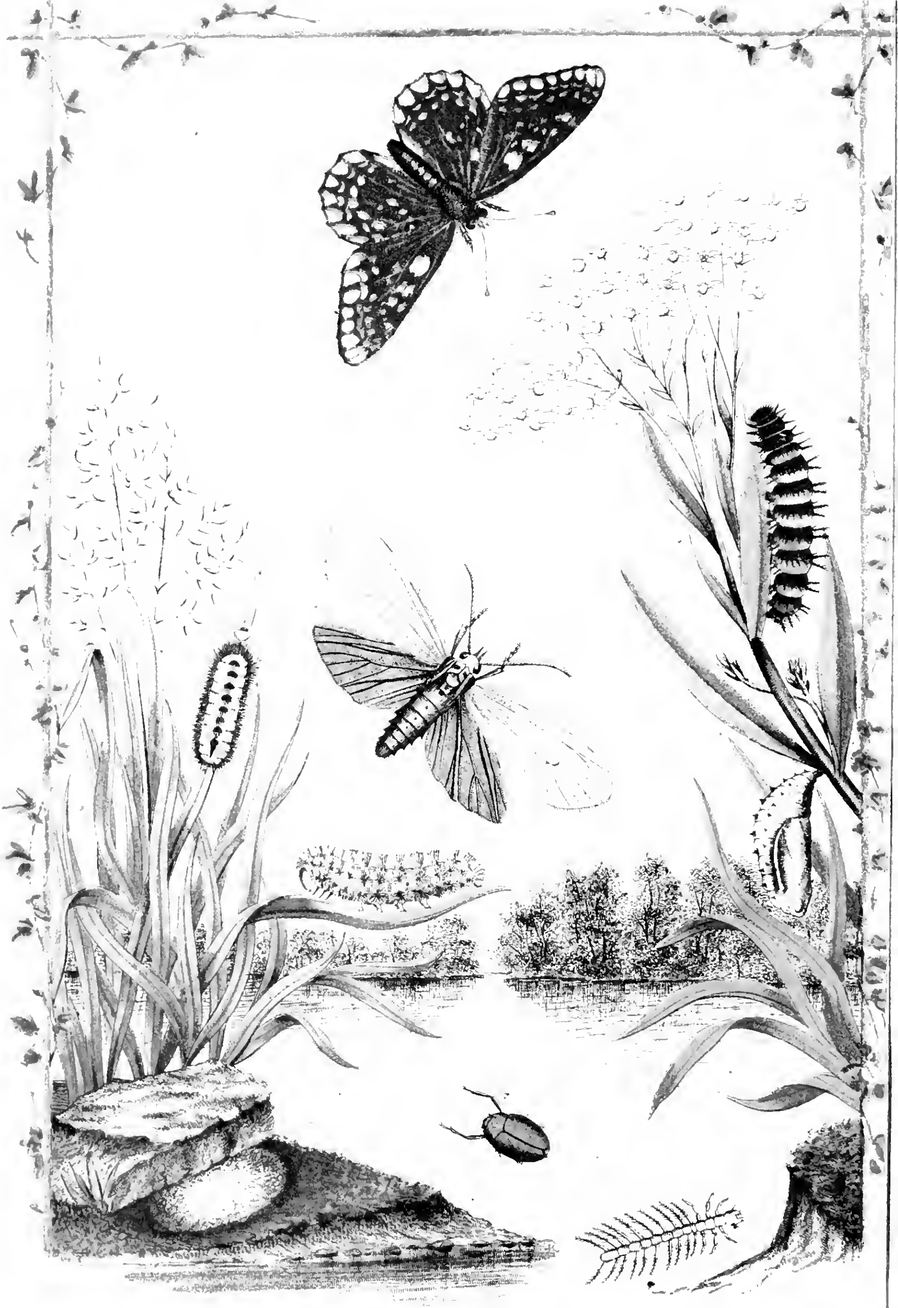
Half Hour Recreations

in

Natural History.



Tompson & Ramsay Imp. Boston

The Metamorphosis of Insects.

HALF HOURS

WITH

INSECTS.

BY

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"GUIDE TO THE STUDY OF INSECTS," "LIFE HISTORIES,"
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BOSTON:
ESTES AND LAURIAT.

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HALF HOURS WITH INSECTS.

1. Insects of the Garden.

ANIMAL and plant life are mutually dependent. Each has a starting point from a simple cell — "the structural unit of the entire organized world." The zoölogist and the botanist, ordinarily travelling in separate realms, seem to meet on common ground while studying the lowest representatives of their respective groups. Indeed some one has compared the animal and vegetable kingdoms to two mountain peaks of unequal height, whose adjoining bases rise from an elevated table land. The naturalist discerns below a wonderful simplicity and agreement in the scenes around him; for life is there manifested in the simplest geometrical forms, and there is no distinction between animals and plants. But as he mounts farther up one or the other of the ascents, his interest is continually excited by the numberless modifications of the simple forms beneath him, and while he finds the loftier elevation teeming with the myriad forms of animal life, yet there constantly occur to him hints and analogies connecting the most complex and highly endowed organizations with the humblest forms he left below.

The question whether animals may not be spontaneously produced still remains an open one; while the discovery of the aquarium which reveals to us the delicate balance existing between animal and vegetable life, and also the alleged necessity of the direct agency of insects in the fertilization

of many plants, are but examples of the multitudes of ways in which this dependence of plant and animal exhibits itself.

The theory of the science of agriculture, now so far perfected, seems adequate to the end. Every year adds to the perfection of the seed to be sown, as agriculturists are paying more attention than formerly to a careful selection of the best fruits and seed. The chemistry of plants, of nutrition and absorption, all the daily routine of plant life, has been mapped out by Liebig and his followers. The care of flocks and herds and their improvement have made our farmers actually better acquainted with the principles of in-and-in breeding, or the secrets of "natural selection" than many naturalists. Indeed, the facts already brought out by practical writers on this subject are important contributions towards a theory of the method and permanent effects of specific variation, a point now so interesting to naturalists.

Agricultural mechanics, in its constant endeavor to lighten toil and economize time, thus leading to the increased intelligence of the laborer, is daily enlarging its borders. New inventions of reaping and ploughing machines and labor saving machinery of every description are constantly devised, so that we may consider the theory of agricultural science far advanced toward perfection.

Now come in some disturbing agencies, such as tempests, prolonged rains, severe droughts, rust, mildew and injurious insects. Their appearance cannot be prognosticated, their direful effects once experienced cannot be immediately remedied, nor the remedies when discovered be always seasonably applied. The last mentioned cause of disturbance will now engage our attention.

Nearly every one can recall the sudden and simultaneous uprising of the army worm in New England during the summer of 1861. Its ravages have been known and dreaded yearly in the western states, where at intervals it has done wide and extensive damage. Though in a local history a

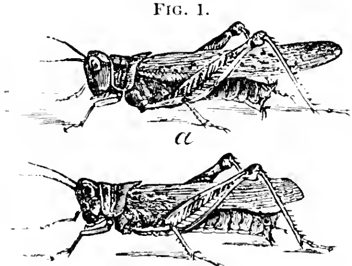
caterpillar answering to the description of the army worm had been noticed in New England at long intervals since 1743, its appearance in 1861 took all by surprise, as hosts of them appeared full grown and busy at their work, foraging upon our wheat and cereals, cutting down field after field of grain as they marched their columns in dense black masses over stone walls and through fences, often bridging ditches filled with tar or burning straw with the dead bodies of their companions; while their ranks were thinned by hosts of domestic fowls and other birds which followed hard upon their rear, or disputed their onward march. They had hardly begun their work in New York, when their appearance was heralded in the vicinity of Boston. But a few days elapsed, and their simultaneous appearance in Bangor, at the Forks of the Kennebec and the limits of civilization on the Penobscot River was announced in the papers, and the cry of their coming was caught up on the river St. John. Millions of dollars worth of grain were lost to the country by the ravages of this one species of caterpillar.

The same season the appearance of the grain aphis in hosts which blackened the tops of waving grain ripening for the harvest, was no less marvellous, as the insect had been comparatively unknown before. The range of the grain aphis was still greater than that of the army worm. Though hundreds of plant lice pitted against one army worm might produce less visible effects, yet the continual depletion by these pygmies in drawing out the sap of the grain stalk must have told upon the quality of the grain and of the seed for several years succeeding.

The strange history of the locust, its wide spread migrations, its sudden appearance and departure, the mysteries of its birthplace, the ruin consequent on its devastations, are familiar to every reader of the Bible, and are repeated in ancient and modern accounts of oriental travel. These scourges of mankind, these insect Vandals and Goths have

their family relatives in this country. Rumors are yearly heard of immense flocks of grasshoppers (Fig. 1 *a*, *Caloptenus spretus*) devastating immense tracts of soil in the farthest west and the Pacific slopes of the Rocky Mountains. In New England and the Canadas our most common grasshopper (Fig. 1 *b*, *Caloptenus femur-rubrum*) has at times emulated the bad fame of the eastern locust. In Williamson's "History of Maine," it is stated that "in 1749 and 1754 the common red-legged grasshoppers were very numerous and voracious: no vegetables escaped these greedy troops; they even devoured the potato tops; and in 1743 and 1756 they covered the whole country and threatened to devour everything green. Indeed, so great was the alarm they occasioned among the people that days of fasting and prayer were appointed, on account of the threatened calamity." Dr. Harris thus quotes from President Dwight's Travels: "Their voracity extends to almost every vegetable; even to the tobacco plant and the burdock. Nor are they confined to vegetables alone. The garments of laborers, hung up in the field while they are at work, these insects destroy in a few hours, and with the same voracity they devour the loose particles which the saw leaves upon the surface of pine boards, and which, when separated, are termed sawdust. The appearance of a board fence from which the particles had been eaten in this manner, and which I saw, was novel and singular; and seemed the result, not of the operations of the plane, but of attrition. At times, particularly a little before their disappearance, they collect in clouds, rise high in the atmosphere, and take extensive flights, of which neither the

FIG. 1.



Destructive Grasshoppers.

cause nor the direction has hitherto been discovered. I was authentically informed that some persons employed in raising the steeple of the church in Williamstown, were, while standing near the vane, covered by them, and saw, at the same time, vast swarms of them flying far above their heads. It is to be observed, however, that they customarily return and perish on the very grounds which they have ravaged." In the western plains the long-winged Caloptenus (*C. spretus*, Fig. 1 *a*) is still more destructive.

I might also cite the annual loss sustained by the attacks of the wheat midge and Hessian fly, the state of New York having lost, according to Dr. Fitch, $12,000,000 worth of wheat in one year. 100,000 bushels of wheat could be raised annually in the state of Maine if it were not for these two insects. Among the more formidable pests in the south and west are the cotton boll worm, army worm and the chinch bug, from which farmers annually lose thousands of dollars.

For the greater or less abundance of insects, as one year succeeds another, one can readily understand that the vicissitudes of the climate, the abundance of a particular kind of food, the temporary absence of parasites and external enemies are sufficient to account. But for the vast numerical increase of insects, which are ordinarily seldom observed, and whose lives at the most span but a few months or weeks, we cannot so satisfactorily account.

Moreover, there are great injuries received from the long sustained attacks, renewed annually, of insects such as the wheat fly and farm and forest insects. A late report of a committee of the French Senate, which we find translated into the "Edinburgh New Philosophical Journal," "states that the wire worm consumed £160,000 worth of corn in one department alone, and was the cause of the deficient harvests which preceded 1856. Out of 504 grains of colza gathered at hazard at Versailles, all but 296 had been rendered worthless by insects. The reduction of yield in oil

was 32.8 per cent. In Germany, according to Latreille, the larva of a species of moth (*Psilura monacha*) consumed whole forests." In Eastern Prussia, three years ago, more than 24,000,000 cubic inches of fir had to be cut down because the trees were attacked by insects.

In view of these facts let us now look at some points in the life of an insect. Though the process of building up the tissues of the body by cell growth had not been distinctly enunciated, Herold had given in the remarkable plates to his "Disquisitiones" clear representations of the gathering of the cells; and, as the result, the faint line of tissues just entering upon the threshold of life in outlines too vague to admit of a guess as to what the future animal might be. Then the division of the elongated body into distinct rings, and the gradual, though but partial, evolution of organs, when antennæ, jaws and legs are all alike to the eye of the beholder, leave it yet a question whether any further development is to be arrested here, and the creature remain the lowest of its type, or still pass on to higher grades, following unerringly the law impressed upon its being. The embryo itself sets the question at rest when it eats its way through its shell, and after devouring its former habitation, as it often does, settles down quickly upon the leaf it is born upon, and forthwith begins its riotous life.

Before Von Siebold had published his tract upon a parthenogenesis* among bees and moths, it was currently believed that the bee grub was developed into a drone, queen or neuter, according to the quality of the food or "bee bread" it was fed with. But this acute and painstaking physiologist, by the aid of intelligent and scientific bee masters in Germany, brought out these astonishing facts in the generation of insects: that the queen bee, after her marriage flight far up in the air, laid two sorts of eggs; that while some of the eggs were, *at the will* of the queen, fertilized and produced workers,

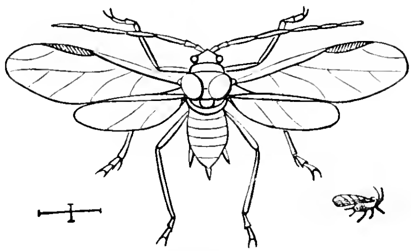
* That is, the production of young from a virgin insect.

others were deposited as barren eggs which, however, were found to hatch out drones. It is also known that one of the young worker larvæ when placed in a separate cell and fed upon a peculiar kind of bread became eventually a queen bee.

These facts give some clew to the anomalies in the generation of plant lice (Fig. 2). Bonnet ascertained that the spring brood of aphides were virgins, which throughout the summer brought forth young alive. In the fall of the year, however, winged individuals of both sexes appeared, and during the winter the species was represented by eggs.

It has since been discovered by able anatomists, with the aid of the microscope, that these spring-born aphides so wonderfully prolific, throw off from a "bud-stock," by a

FIG. 2.



Aphis or Plant Louse.

process analogous to the budding and leaving out of plants, or to the dropping off of hydroid medusæ from their polyp-stalks, whole multitudes of young plant lice, which mature rapidly without passing through the intermediate stages of egg, larval and pupal life common to most insects. As if nature, in her exceeding haste to fill up her quotas of millions of ready made sappers and miners of vegetable life for the summer campaign, had disregarded all rules in her otherwise well regulated house. In this connection we may refer to Dr. Fitch's enumeration of the number of the Cherry Aphis, produced between the 15th and 25th of June, and how these immense numbers are reduced by insect enemies :—

"This species commences to appear as soon as the leaves begin to put forth in the spring. * * * They bring forth their young alive during the continuance of warm weather. These huddle around their parents upon the under surface of the leaves as closely as they can crowd themselves; indeed they often are found two deep, a portion of the colony standing upon the backs of the others, requiring only sufficient space between them to insert their beaks into the leaves to suck their juices. The numbers which thus make out to stow themselves within a narrow compass are almost incredible. Upon the under surface of a small leaf three-fourths of an inch long and half an inch wide I have counted upon one side only of the midvein one hundred and ninety of these lice. Yet this leaf was not more densely covered than many others. The surface of a small leaf but an inch long would therefore furnish ample space to accommodate a thousand of these insects. * * * Among the cherry trees alluded to above was a row of seven young ones which had attained a height of about ten feet. By counting the number of leaves upon some of the limbs and the number of limbs upon the tree, I find a small cherry tree of the size above stated is clothed with about seventeen thousand leaves. And at the time alluded to these leaves could not have averaged less than five or six hundred lice upon each, and there were fully a third more occupying the stems and the tips of the twigs. Each of these small trees was therefore stocked with at least twelve millions of these creatures. And yet so vigilant, so sharp sighted and voracious were their enemies that at the end of a few days the whole were exterminated."

This may help us to explain why males of certain species of gall flies have never been discovered, though a German entomologist has examined over two thousand females of one species, and not a foreign element occurred in this nation of Amazons. Mr. Walsh has, however, discovered that in an American species of gall fly, the spring brood consists of

both sexes, while the autumnal brood is composed exclusively of females. Again in some species of moths where the two sexes are of equal abundance Von Siebold found that it was no unusual thing for individuals to be hatched from eggs known to be laid by a previous virgin generation.

Fairly entered upon the duties of active life the young larva is capable of doing wonders in gastro-dynamics. It would seem with most insects as if all the eating for their lives were concentrated into this stage of their existence. For there is a period coming of long cessation from activity, when, in external immobility and seeming lethargy, wonderful transformations pervade nerve and muscular tissues; a new body, wonderfully differentiated for a new existence in a far more extended sphere than formerly, is taking on its form beneath the rough and often unsightly pupa.

After the last moulting the power and desire of eating are lost, increased stores of fat are laid up for the sustenance of the pupa, and the wings and legs of the future fly are forming. The worm seeks a shelter and often spins a cocoon of silk, and there, in quiet and away from the light, its functions of animal life suspended and a very slow vegetative existence barely sustained, as a chrysalis the insect spends a portion of its life.

The knowledge of the fact that all animals pass through some sort of a metamorphosis is very recent in physiology; moreover the fact that these morphological eras in the life of an individual animal accord most unerringly with the gradation of form in the type of which it is a member, was the discovery of the eminent physiologist Von Baer. Up to this time the true significance of the luxuriance and diversity of larval forms had never seriously engaged the attention of systematists in entomology.

What can possibly be the meaning of all this putting on and taking off of caterpillar habiliments, or in other words the process of moulting, with the frequent changes in orna-

mentation, and the seeming fastidiousness and queer fancies and strange conceits of these young and giddy insects, which seem hidden and mysterious to human observation?

We can only answer that the changes in form are necessary stages in the growth of the animal, and correlated with certain habits enabling it to hold its own in the struggle for existence.

We should apply our knowledge of the larval forms of insects to the details of their classification into families and genera, constantly collating our knowledge of the immature forms with the structural variations that accompany them in the perfect state. The simple form of the caterpillar seems to be a concentration of the characters of the perfect insect, and presents easy characters by which to distinguish the minor groups; and the relative rank of the higher divisions would seem to be definitely settled only when the form and method of transformations are thoroughly known.

The pupa state is the threshold upon which the young insect pauses before it enters upon the final stage of its existence. Though called chrysalides because the pupæ of certain butterflies are gaily ornamented with golden and silvery spots, the most of them are dull and ugly. Whether it is owing to their uninteresting appearance, or the difficulty of finding them, entomologists have very generally overlooked the consideration of their forms and have underestimated the value of the differences that the pupæ of different insects present. There is in them, more than in the caterpillar, or perfected state, a constant form by which we can readily recognize the family to which they belong; and even in the slight modifications of that persistent facies together with the slight attempts at ornamentation, which Nature seems always to be striving for in the rudest of her works, the student whose mind is upon the watch for the meanings of these slight variations will be richly rewarded. Just as insects have been classified by their larval characters, which

have always agreed with those drawn from the imago, can they again be arranged in a natural method by the sole consideration of their chrysalid characters.

When the insect breaks forth from its chrysalis, we can then see how wonderfully complex is the outer crust that gives form to the creature and protects its vital parts. At first sight we see the body divided into three portions, to which naturalists give the name of head, thorax and abdomen, terms borrowed from the anatomy of man himself, and to be retained in science only until more appropriate names are suggested. It is as if we should take a wormlike, cylindrical figure consisting of successive rows of cylinders, and should constrict it in two places, thereby dividing the whole body into three sections or regions. Of these regions the first is the smallest and most unlike the two others in shape, and besides organs of special sensation is provided with chewing organs, while within is an enlarged pair of nerve knots serving as some sort of a brain, though hardly larger than those supplying the remainder of the body. This region constitutes the head.

Larger than the head, inasmuch as it is to support the organs of locomotion, is the middle region or thorax, which supports the legs and two pairs of wings; while the largest portion of the body is the bulky abdomen, which retains very much of the original wormlike form of the larva, and is the seat of the reproductive system. But were the contour of the rings that make up these sections of the hard outer crust still continuous and unbroken, we should have the poor victims enclosed in jackets of the straitest kind. Whence comes then all the grace and freedom of action that the butterfly and ichneumon-fly possess? It is in the fact that the whole outer crust is subdivided into portions finely hinged together by tough membranes, and forming points of attachment to thousands of little muscular fibres within, thus giving it a surprising degree of flexibility. Besides these

pieces, of which there is a definite number to each of the thirteen segments or rings that compose the body of every insect, exclusive of the head, which is supposed to consist theoretically of four segments, we have to consider the numerous joints of the antennæ, of the mouth parts which consist of three pairs of appendages, and of the legs. We see therefore that descriptive entomology has to take account of several hundred distinct pieces, which by changes in their relative size and position produce the immense range of variation in the half a million species which are found living or dead upon the earth. Thus the idea of articulation upon which Cuvier founded this branch of the animal kingdom, which begins so simply in the worm and grows more complex in the crab and its allies, in the insect is carried out with a richness and profusion of detail that is almost bewildering. It is like comparing a boat dug out of a log to the Great Eastern, or an Indian's wigwam to the cathedral of Milan.

Our frontispiece conveys an idea of the metamorphosis of a butterfly, a moth and a beetle. The butterfly is the pretty *Melitæa Phaeton*, which flies in June and July. Its caterpillar feeds on the golden rod, and when it transforms into the pretty white chrysalis, fastens itself by the tail to the stem of the plant and hangs head downwards, awaiting its final change into the butterfly.

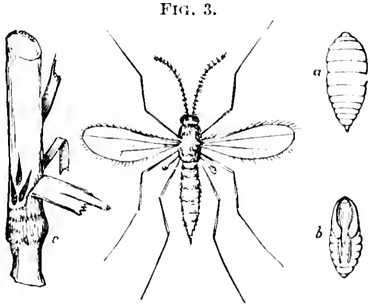
The moth whose transformations are represented on the left of the plate, is the *Ctenucha Virginica*. It is a dark blue insect which flies in the hottest sunshine, contrary to the habits of the majority of moths. Its caterpillar, which feeds on grass, is like the Hairy Bear of our gardens, and constructs under stones a pretty cocoon of hairs which it plucks from its own body.

The water beetle is the common Gyrinus or whirligig beetle, so commonly seen gyrating in small parties over the surface of our ponds. Its singular larva is long and slender, with long fringed breathing appendages along the sides of the body.

After all the insects interest us most when we study their psychology and habits. From what little we know of their psychical endowments, we see enough to convince us that as physically they occupy a middle ground between ourselves and the lowest and simplest of animals, so in their instincts they seem to maintain a corresponding relation. They have, what is the common property of all animals, enough intelligence to meet the exigencies of life. They possess apparently like passions with ourselves, so much so that we find ourselves unconsciously judging of their actions by our own feelings. Hence to our senses they hate and love, show fear and revenge, enjoy their moments of repose from toil, engage in sports, carry on wars, live a hermit life or are gathered into commonwealths, and are capable, individually, of some degree of education.

All this great diversity among insects in form and accompanying adaptation of instinct and reason are subservient to the part these animals are to play in nature. There are no neutral, non-committal characters among insects. The agriculturist classifies them into two categories, the friends and foes of his crops—according as they are carnivorous or herbivorous; and it is necessary for him to distinguish carefully between them. This is often a difficult matter, for as we descend in the scale of animal life we find those broad lines of demarcation which separate animals of different habits growing less distinct. In some tribes which resemble each other so closely that only educated eyes can distinguish them, we have species of totally different habits. Thus the Hessian fly (Fig. 3)

FIG. 3.



Hessian Fly: *a*, larva; *b*, pupa.

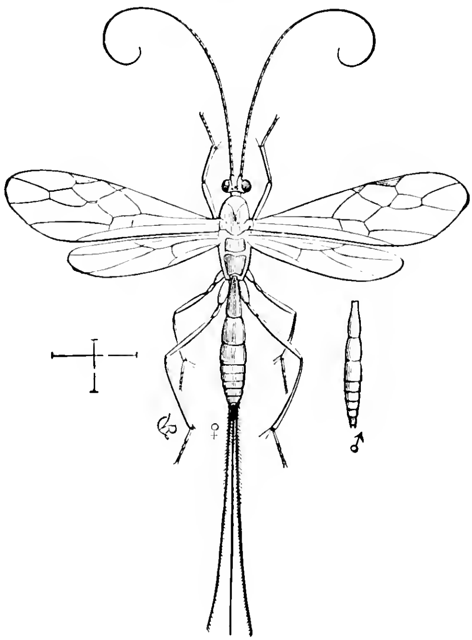
which swarms over our wheat-field might easily be mistaken by the farmer for what seems to him to be merely small or "young" mosquitoes, so similar are the mature stages of the two: though when a larva the one preys upon our crops, and the other does service to mankind as a scavenger of our ponds and pools. So also the bed bug, which we can with safety pronounce to be essentially a blood-sucker, has many allies which are innocuous sap-suckers. Indeed our wonder is continually excited at finding insects of very similar form with habits of life most strikingly opposed.

Any account of the natural history of an insect would be very imperfect, were the habits and description of the peculiar parasites that check the increase and diffusion of the species left unrecorded. All animals and many trees and plants are exposed to annoyance from the continued attacks of other species, without having their actual existence endangered; but among insects the term parasitism has another and extraordinary meaning; since besides those minute forms of lowly organized life which only harass without inflicting more serious injury, we have an immense number of insects high in the scale of organization, which subsist upon other insects only to kill and destroy them utterly. Thus of the ordinary parasitic plants and animals which always live on insects Dr. Leidy has given us in his "Flora and Fauna within Living Animals" published in the "Smithsonian Contributions to Knowledge," some representations, of remarkable delicacy and beauty, of miniature forests of microscopic plants which line the alimentary canal of several sorts of ground-inhabiting insects. There are not wanting here even divers sorts of low and exceedingly minute worms, part of whose office it may be is to restrain and keep within bounds the vegetation which luxuriates in those strange passage ways.

In the other form of parasitism the insect devours all the soft parts of the body of its victim, leaving but the empty

crust in its place. Now there are two conditions to be fulfilled in this act of parasitism; for the insect preyed upon must maintain its hold upon life, feeble as it may be, long enough to enable the enemy lurking within, to build up its tissues and add to its own strength by daily depleting from

FIG. 4.



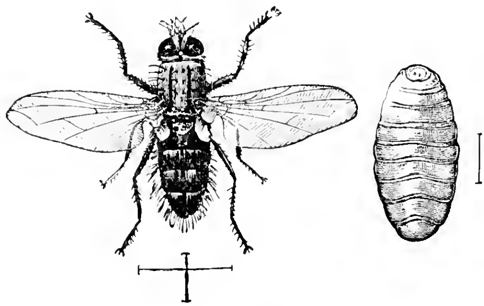
Ichneumon (Macrocentrus).

the stores of vitalized food about it; and on the other hand the parasite must carefully avoid touching the vital parts of its host. It must content itself with feeding upon the fatty portions alone of the body.

That family of the Hymenoptera of which the ichneumon-fly (Fig. 4) is a type, and many species of true flies

(Fig. 5) bearing a close resemblance to the common house-fly, are devoted to this work of parasitism-extraordinary. The process is thus: the parent fly lays its eggs within or upon the body of its victim, most commonly a caterpillar which is full-grown and about to enter upon its transformations. The young worm hatches and feeds upon the large stores of fatty tissues which surround the vital organs of its host. How very nice must be the adjustment of relations between the two animals, when in the case of the parasite, the slightest deviation from its path involving any injury to the neighboring nerves or vessels of its host will bring

FIG. 5.



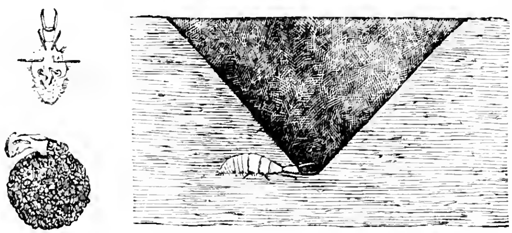
Tachina and larva.

eventual ruin to itself by hastening the death of the caterpillar! This delicate balance between the growing parasite and wasting victim may continue through the chrysalid state of both insects, until just as we think the butterfly will break its prison walls, lo! the trim, neat form of its unrelenting enemy steps forth from its body ready armed and equipped for active service.

The late Mr. Herrick some years ago announced the discovery of the fact that the eggs of the canker worm were preyed upon by a minute ichneumon-fly. Here is an anomaly—an egg nourishing its inhabitant and immersed in the

contents of another egg! We have had the pleasure of watching the labors, late in autumn, of this little insect, whose length measures not over three hundredths of an inch, as it was busily engaged upon a bunch of eggs under our object glass, with a restless anxiety to rid itself of its burden of infinitesimal eggs by pushing them through the walls of those upon which it stood. Each egg developing perhaps simultaneously, we can imagine the race and struggle for existence in that tiny enclosure. The germ of the larger worm rapidly collects and arranges the elements of its own form, but it is in vain; for the smaller being of a more rapid growth is stealthily and unawares as constantly pulling

FIG. 6.



Ant-lion.

down that structure of cells and tissues. The race is not always to the strong.

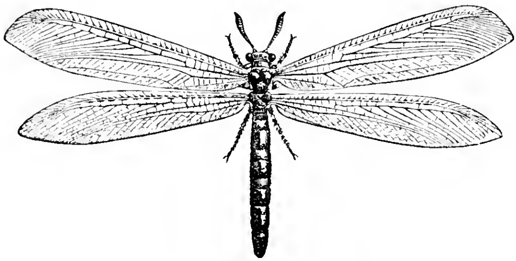
It often happens that several species of these parasites feed upon a single kind of caterpillar. Thus upon the army worm six species of ichneumons are known to exist, and a Tachina fly is extremely destructive to it. Baron Humboldt tells us in the "Views of Nature" that "Bombyx Pini, the Pine Spinner, the most destructive of all the forest insects in Europe, is infested, according to Ratzeburg, by no less than thirty-five species of parasitical Ichneumonidæ."

We have incidentally alluded to the agency of carnivorous insects in diminishing the numbers of vegetable feeders. The appellation of ant-lions (Fig. 6, ant-lion in its hole;

Fig. 7, adult), aphis-lions, tiger beetles, water tigers (Fig. 8) and dragon-flies, names borrowed from their fierce four-footed namesakes, are significant of the fierce passions and insatiable appetites of their six-footed copyists.

We were one autumn reminded of the great value of having

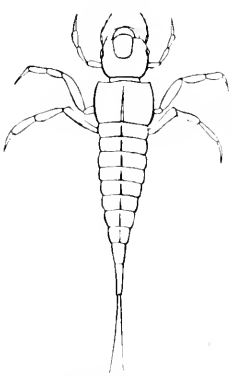
FIG. 7.



Ant-lion, adult.

a brood of martins or swallows about the farm and garden, when a storm prostrated a martin box, and one of its compartments was found literally packed with the dried remains of the little yellow and black squash beetle. The great and efficient aid of birds is too apparent to be passed over lightly. We quote again from the Report of the French Commissioners upon this subject. "The commission excludes birds of prey, such as magpies, ravens, etc., with the exception of buzzards and rooks, from the benefit of its protection, because the buzzard consumes about six thousand mice yearly. The rooks eat an incalculable amount of white worms. Sparrows, once thought harmful as eating grain, are restored and their usefulness shown by reference

FIG. 8.



Water Tiger.

to the fact, that when their destruction was attempted in Hungary, winged insects increased so rapidly that rewards for the destruction of sparrows were suppressed, and others given for bringing them back.

"Frederick the Great ordered the destruction of sparrows because they ate his cherries, but in two years' time he found his cherries and all other fruits consumed by caterpillars. In a sparrow's nest on a terrace in the Rue Vivienne were found the remains of seven hundred cockchafers. Owls and birds of that class which agricultural ignorance pursues as birds of ill omen ought to be welcomed. They are ten times more useful than the best cats, and not dangerous to the larder. The martins that were killed, were found to have in their stomachs the remains of five hundred and forty three insects. The commission recommended a prohibition of bird-nesting and the destruction of eggs or young birds." We must not kill any birds: even those that in the late summer pilfer from our orchards, at other times eat multitudes of worms. It will not do to destroy the balance of nature.

The study of insects has been too much confined to their classification and the synonymy of the species. It is only occasionally that we see naturalists whose dispositions and opportunities lead them to study habits exclusively, or to combine the two departments of study. DeGeer and Reaumur of the last century, whose ponderous tomes are packed with observations of insect economy, many of which have never since been repeated, laid the foundation of these inquiries. The labors of the Swedish Count and French natural philosopher are monuments of patient research and curious inquiry.

Here also should be noticed Ratzeburg's great work on forest insects. In the elaborate and beautiful plates, fifty-seven in all, that enrich the two volumes of this distinguished entomologist, is reproduced the tree as it stands

in the forest, gnarled and distorted by one set of insects, its leaves curled and turned yellow or red by the attacks of others, with certain branches stripped by still others; and not only are certain trees and shrubs thus represented in colors, but some of the plates represent parts of a forest, showing the injury done in the mass by one or two species of insects, with the changes in the form of branches and leaves for several years succeeding the defoliation, and the after growth of branches depending on the different degrees of injury, with transverse sections of the twigs, and microscopic sections illustrating the pathological anatomy of the tree. In England Curtis' "Farm Insects" and in our own country Harris' Treatise on the Injurious Insects of Massachusetts, together with Fitch's reports on the injurious insects of New York, and Walsh's on those of Illinois, Riley's on those of Missouri, LeBaron's on those of Illinois, Trimble's work on the insects injurious to fruit trees, and the reports of the writer on the insects of Massachusetts, all elucidate the subject of applied or economic entomology.

Indeed the study of economical entomology is of growing importance. Every passing year witnesses the attacks of new enemies of our crop that appear as the forests are cut down, and their natural food plants destroyed. The wanton killing of insect-eating birds also tends to a steady increase in the number of noxious insects. More knowledge of entomology should be diffused among agriculturists, that they may be made acquainted with these pests and be forewarned against their attacks and thus save a fair percentage of their crops.

We begin in this number an account of the insects of the garden, and as their name is legion we shall have to select a few of the most noxious, and portray as clearly as possible their forms, and briefly sketch their habits.

Were we to enumerate all the insect pests which gather about our flowers, garden vegetables, ornamental shrubs

and fruit trees, the list would extend to several hundreds. A few of these, such as the imported cabbage butterfly, apple bark-louse, the vaporer moth, the gooseberry saw-fly and others are importations from Europe, while the still more injurious canker worm, tent caterpillar, apple tree borer, pear slug, and more that could be mentioned are natives, and before the apple and pear were introduced probably fed on the species of wild cherry, thorn and other rosaceous plants common in our woodlands.

In speaking of the great number of injurious insects which infest certain plants, I may be pardoned for quoting as follows from my first "Annual Report on the Injurious and Beneficial Insects" made to the Massachusetts Board of Agriculture.

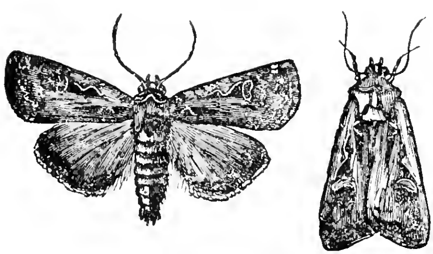
"We should not forget that each fruit or shade tree, garden shrub or vegetable, has a host of insects peculiar to it, and which year after year renew their attacks. I could enumerate upwards of fifty species of insects which prey upon cereals and grasses, and as many which infest our field crops. Some thirty well known species ravage our garden vegetables. There are nearly fifty species which attack the grape vine, and their number is rapidly increasing. About seventy-five species make their annual onset upon the apple tree, and nearly an equal number may be found upon the plum, pear, peach and cherry. Among our shade trees, over fifty species infest the oak; twenty-five the elm; seventy-five the walnut, and over one hundred species of insects prey upon the pine."

Cut Worms.—Among those general pests, which have no special food-plant, and from their omnivorous tastes do infinite mischief in gardens, are certain sly, nocturnal creatures, the cut worms. They have the well known habit of cutting off with their jaws the young, succulent plants of the cabbage, turnip, bean, tomato, corn and various cultivated flowers.

These caterpillars are usually cylindrical, the body taper-

ing slightly towards each end, with a horny crescent-shaped plate on the segment preceding the head. They are usually livid greenish, or ash gray, with darker stripes along the body, which is either smooth or slightly warty. At rest they may be found curled up under sticks or stones in the grass, or under boards,* etc., left carelessly in the garden. They transform within a rude earthen cocoon or chamber under the ground, into a brown chrysalis which may often be found at the roots of corn, grass, etc. The worm may be found late in spring and early in summer. The parent moths fly late in summer and in September, and while most of the family (Noctuidæ) fly only by night, these Dart Moths, as they are called, from their rapid, headlong flight, may be seen in the hottest days about the flowers of the golden rod.

FIG. 9.



Gothic Dart Moth.

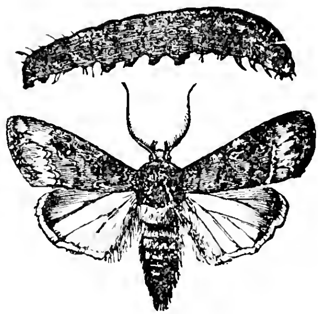
Our commonest species is the Gothic Dart Moth (*Agrotis subgothica* Fig. 9). The young of this modest moth is said by Mr. Riley, who has reared it, to be an inch and a quarter long, of a dirty white or ash gray, with sometimes a yellowish tinge. Along the back is a whitish line, edged on each side with a dark one. On the side are three lateral dark broader stripes, the lower one the widest.

Another common, but still larger, Dart Moth is the Lance Bearer, *Agrotis suffusa* of European authors, or *A. telifera* of Harris (Fig. 10). Mr. Riley calls its caterpillar the "Large Black Cut Worm." It is an inch and a half long, dull brown above, with a distinct pale line on each side of the middle of the back. Between these lines and the row

of breathing holes are two more pale lines. There are eight black shining minute warts on each segment, each wart bearing a short hair.

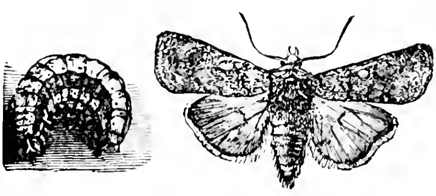
A third species of cut worm, whose parent was called by Harris the Clandestine Moth (*Noctua clandestina*), is next to the Gothic Dart Moth, our most common species and may be found by day hiding under boards, etc. It flies only by night. It is a blackish moth with obscure markings. Its caterpillar is called by Riley the W-marked Cut Worm. It is an inch and an eighth long, and is "ash gray, inclining on the back and upper sides to dirty yellow; it is speckled all over with black and brown spots." He adds, that besides the usual lines on the side, "the distinguishing feature is a row of black velvety marks along each side of the back, on all but the thoracic segments [*i. e.*, the three succeeding the head] bearing a general resemblance (looking from tail to head) to the letter W."

FIG. 10.



Lance Bearer.

FIG. 11.



Cochrane's Dart Moth.

These may be regarded as examples of the group of cut worms, of which we have numerous forms. All, however, seem to agree in the special mode of attack. They cut young plants square off, near the ground, and then luxuriate on the soft pulpy centre of the stalk. One species in the west (*Agrotis Cochrani*, Fig. 11) ascends pear and apple trees

and grape vines, eating off the fruit buds; while another larva, not of a true Agrotis however, in New England cuts off the soft fresh shoots of the currant.

Mr. Cochrane says that the western moth always prefers "to lay her eggs near the hill or mound over the roots of the trees in the orchard and if, as is many times the case, the trees have a spring dressing of lime or ashes with the view of preventing the operations of the May Beetles, this will be selected with unerring instinct by the miller, thus giving her larvæ a fine warm bed to cover themselves with during the day from the observation of their enemies." It is probable that the females of all the Dart Moths deposit their eggs at the roots of grass, stubble, etc., in the summer and early autumn, and sometimes in the spring. It is a weighty reason for burning all stubble or ploughing it under as deeply as possible, that the eggs of many insects and indeed various insects themselves are thus destroyed. Nearly all these moths frequent grass lands, and rise from the ground on being disturbed, fly off in their headlong course a few yards and drop down towards the roots of the grass.

According to Riley the eggs hatch out, and the larvæ acquire two-thirds their size when winter overtakes them; they then descend below the reach of the frost, there remaining torpid until the warmth of spring calls them to the surface. In a few species the winter is passed in the chrysalis state.

Cut worms hide by day under stones, boards or sticks, or in gardens burrow into the dirt to avoid the light and heat. At dark they come up to the surface and usually, according to Mr. Coleman ("American Naturalist," June, 1873), appear regularly, those that he watched coming up at nine o'clock. He observed that the worm fed upon the grape in the following manner. "The worm would come out of the ground at its usual time, ascend the vine till it came to a new shoot,

gnaw that off and fasten itself to the stump of the branch so gnawed and suck the sap of the vine till it was so full that it seemed almost ready to burst, then descend to the ground and bury itself out of sight."

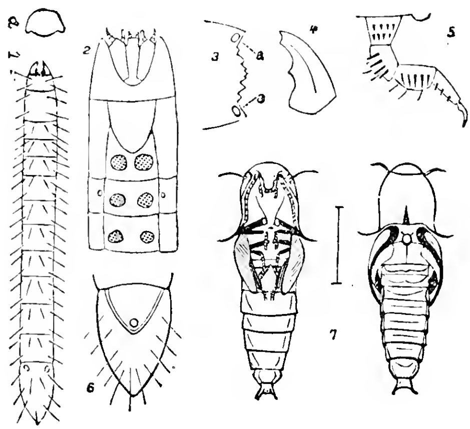
It is well known that a roll of paper or tin surrounding the plant and its roots is the best preventive against the insidious attacks of the cut worm. Mr. Cochrane in dealing with the Apple-bud Cut Worm says, "there is no known remedy, salt has no properties repulsive to them; they burrow in it equally as quick as in lime or ashes. Tobacco, soap and other diluted washes do not even provoke them; but a tin tube, six inches in length, opened on one side and closed around the base of the tree, fitting close and entering at the lower end an inch into the earth, is what the lawyers would term 'an effectual estoppel' to further proceedings."

The best remedy is, then, to watch for the worms at dark or dig around the roots by day and kill by pressure under foot. The next best remedy is to surround the plant with a roll of paper or pasteboard, and avoid the use of nostrums recommended to kill the worm. It is also a good plan to set boards under which the worms are inclined to hide; they should be examined every day and the worms if found killed. Riley suggests that many cut worms may be entrapped by making smooth holes with a stick and examining them the next day, when the worms may possibly be found at the bottom.

The Wire Worm.—Another universal plague in gardens is the wire worm. It is omnivorous in its tastes, feeding on the roots of grain, lawn grass, various flowers and vegetables, and in some cases attacking fruits and flowers. They occur in all sorts of places, but more abundantly than elsewhere under the bark of trees and stumps, where they feed on the decaying wood and thus are not harmful. We have between one and two hundred species in this country. The

accompanying figure* (12) taken from the Report of the Entomological Society of Ontario, Canada, for 1871, represents the larva and pupa of a common form (*Agriotes mancus*) which is very injurious to wheat. The wire worm is readily known by its smooth, slightly flattened cylindrical hard reddish body. Mr. Johnson Pettit, who has made us fully acquainted with the habits of the wheat wire worm, says that it lives three years in the larval state. He obtained a knowledge of its habits by planting wheat in flower pots. He

FIG. 12.



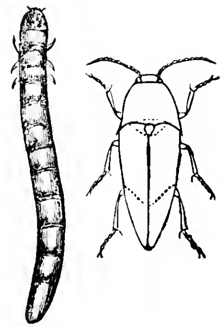
Wheat Wire Worm.

found the grubs in the autumn, "with the first cold weather they ceased to eat and were then placed in a sheltered situation until the return of warm weather in the spring, when they were restored to the breeding cages. They soon gave evidence of being alive and possessing unimpaired appetites;

*1. Larva, enlarged a little over three times, *a*, a transverse section. 2. Under side of the head and three succeeding segments. 3. Margin of the front; *a*, position of the antennæ. 4. Mandibles. 5. Legs. 6. Under side of the last segment of the body. 7. Upper and under side of the pupa, the line between representing the actual length (after Horn).

their rapid consumption of the wheat plants rendered it necessary to renew the supply quite as often as before. They were fed in this way until the month of July. On the 26th of August one of the grubs changed into a pupa and on the 3rd of September the first beetle appeared. It is a pale reddish brown insect. This insect and its allies are called click or snapping beetles from their power of throwing themselves up in the air in order to right themselves whenever placed by accident on their backs.

FIG. 13.



Snapping Beetle and larva.

Figure 13 represents the grub and beetle of another wire worm which, according to Mr. Walsh, lived in decaying wood in his breeding jar for a period of two years. Figure 14 (enlarged four times) represents a small slender wire worm found by Mr. Sanborn in the roots of the squash vine. Another form (Fig. 15 enlarged twice) is a common wire worm in the northern states. Allied to the northern elaters, or snapping beetles, is the Cuban fire fly (Fig. 16) which has two large luminous eye-like spots on each side of the thorax, and another at the base of the hind body beneath. We have, in New England even, a phosphorescent wire worm (Fig. 17, Melanactes) which sends out a dull greenish light at night.

FIG. 14.

Wire Worm.

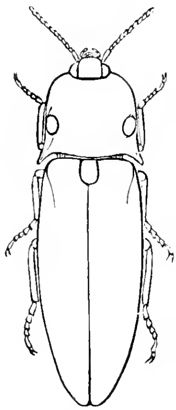
FIG. 15.

Wire Worm.

We cannot, in speaking of remedies, do better than quote from Mr. Bethune's report. "Lime and soot, to be applied to the soil before sowing any grain, are highly recommended by some, but are of doubtful efficacy.

Salt on sandy soils is considered to be efficacious, but not on heavier clay lands. In a garden or small field they may be got rid of by strewing about slices of potato, turnip or apple, and examining the under sides every morning, when numbers will usually be found feeding upon the bait.

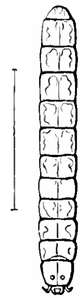
FIG. 16.



Fire Fly.

Moles are very useful in destroying them in meadows, and a large number of our small birds devour them with avidity; ducks, turkeys and fowls will pick them up in ploughed fields, and toads are not averse to making a meal upon them. Our advice then is, break up and fallow the infested wheatfields, ploughing often, and burning up the rubbish; and encourage in every way the farmer's best friends, the small birds. Make it an absolute law of the household that not one of them is to be shot or stoned, get your neighbors to do the same, and believe us, not many years will pass before you will find your insect plagues enormously diminished." The concluding remarks apply with much force in dealing with all our noxious insects.

FIG. 17.

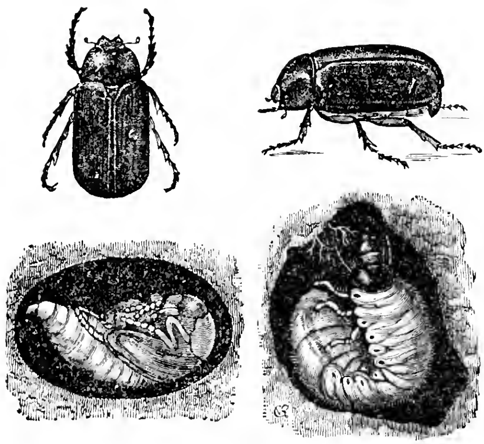


Luminous Wire Worm

The May Beetle.—(Fig. 18, larva, pupa and beetle, after Riley.) Our readers may recognize old acquaintances in the insects here figured. The grub or white worm is abundant in gardens, lawns and grass lands, and the parent beetle or Dor-bug is the insect which so pertinaciously taps against our windows at night, and if successful in effecting an entrance, wheels its "droning flight" about the room to the terror and confusion of those within. The grub is a large, soft-bodied, fleshy, white worm, as thick as the little finger, about an inch and a half long, with a honey-yellowish or pale horn-colored head. Its skin is so thin and trans-

parent that the air vessels and viscera can be seen through it, and though it has three pairs of rather long legs, it is so

FIG. 18.



May Beetle and young.

gross and unwieldy that it lies flat on its side when dug out of its retreat in the soil.

In this state the grub lives three years. The series of changes the insect passes through in its whole existence is as follows: in the months of May or June the beetles pair, and the females lay from forty to fifty eggs in loose dirt below the surface. These eggs, according to Mr. Riley, hatch in the course of a month, and he adds that the grubs growing slowly, do not "attain full size till the early spring of the third year, when they construct an ovoid chamber lined with a gelatinous fluid." This fluid hardens, we may add, forming a glazed inner wall. The chrysalis, or pupa (Fig. 19), may be found in these cells about six inches under the surface in May, and rarely in the autumn.

FIG. 19.

Pupa of May Beetle.

During the latter part of May and early in June in New England, namely, for about a month, the beetle flies about at night, being most active in warm, damp weather, especially before thunder storms, a period when most insects are restless.

By day our beetle in its sober garb of chestnut-brown hides in the foliage of trees, especially the apple, clinging to the under side of the leaves by its long curved claws, which are admirably adapted for the purpose. During winter the grub descends below the reach of frost, and at the approach of warm spring weather wriggles up towards the surface.

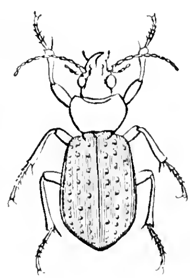
The European Cockchafer has much the same habits as our May-chafer, and when we say that in 1866 the grubs of the Cockchafer destroyed in the department of the lower Seine over $5,000,000 worth of garden vegetables, we fear we are prophesying a state of things that may ensue in America when our population becomes as densely crowded as in the old countries of Europe.

M. Reiset (see "American Naturalist," vol. ii, 209) says that this insect is three years in arriving at its perfect beetle state. The larvæ (grubs) hatched from eggs laid by the beetles which appeared in 1865 passed a second winter, that of 1867, at a mean depth in the soil of nearly a foot and a half. The thermometer placed in the ground (which was covered with snow) at this mean depth never rose to the zero point (or 32° Fahr.) of the Centigrade thermometer, as *minimum*. Thus the larvæ survived after being perfectly frozen (probably most subterranean larvæ are thus frozen and thawed out in the spring). "In June, 1867, the grubs having become full-fed, made their way upwards to a mean distance of about thirteen inches below the surface, where, in less than two months, they all changed to the pupa state, and in October and November the perfect beetle appeared. * * * * The immature larvæ, warned by the approaching cold, began to migrate deep down in the soil in October,

when the temperature of the earth was ten degrees above zero (Centigrade); as soon as the snow melted they gradually rose towards the surface."

The mischief done by the grub of the May beetle is at times almost incalculable. In lawns and grass lands it eats the roots of grass. Dr. Harris, in his well known Treatise, says that "in many places the turf may be turned up like a carpet in consequence of the destruction of the roots." We have lately ascertained that it seriously damages strawberry plants, being undoubtedly introduced in the manure. It eats the main roots, and so large and voracious is this worm that the roots of one plant must form a light meal for them, and a dozen or so of the worms would be enough to ruin a small bed of strawberry plants. It is obvious, then, that if we observe a plant to wilt and suddenly die, the "white worm" is at the roots. It should be dug up, and crushed beneath the foot. It also eats, in a still more summary manner, young squash plants, when they have thrown out three or four leaves, so that gardeners have been obliged to plant the seed over once or twice.

FIG. 20.



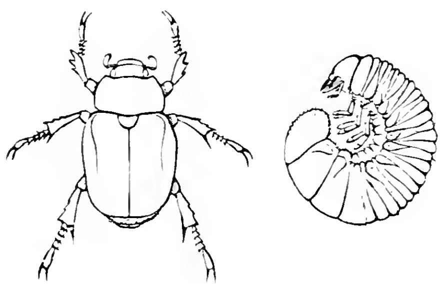
Calosoma calidum.

As to remedies against this grub, the careful gardener will in the first place destroy every grub turned up by the plough or spade. When the top dressing is spread over the bed, he would do well to examine it carefully for these conspicuous worms. When a vine is seen to die down suddenly in summer he must then dig around the roots and search for the aggressor. It is better to spend much time and money for two or three years in succession in endeavoring to exterminate these grubs than to yield passively to the scourge. It is well known that crows and small birds feed upon them in corn fields. Skunks and moles are efficient aids in killing both grubs and beetles, and the larger carnivorous beetles, such as the Calosoma (Fig.

20), devour the beetle itself. In certain favorable years the May beetle is fearfully abundant. It is then necessary to resort to hand picking. If the French take the pains to practise picking their chafers off the plants by hand, so that in one instance about 80,000,000 were collected and destroyed in a single portion of the department of the Lower Seine, our gardeners can afford to take similar care.

The Goldsmith Beetle (Fig. 21).—Of very similar habits is an ally of the May beetle, the beautiful woolly yellow beetle, which is as varied in its tastes as the May beetle. The insect in the beetle state feeds on the young, tender leaves of the pear, elm, hickory, poplar, oak, sweet gum and blackberry; while the grub does much mischief to the roots of strawberry plants. The grub is white, with a yellowish head, and closely resembles that of the May Beetle, simply differing in having longer antennæ and feet.

FIG. 21.

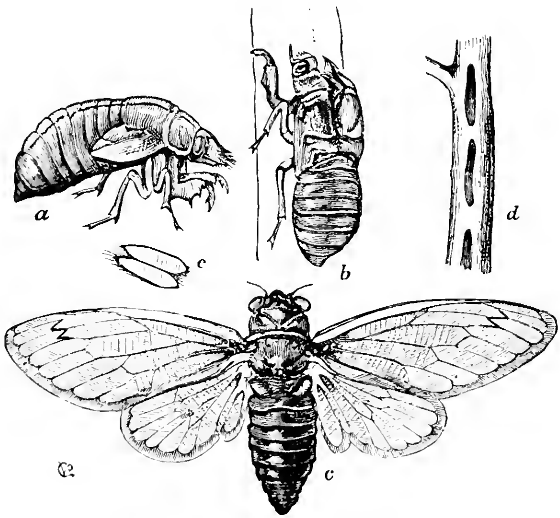


Goldsmith Beetle and larva.

Rev. Dr. Lockwood has made us acquainted with the habits of this destructive chafer. In the middle of June in New Jersey the beetle lays in the night about fourteen eggs in the soil, each egg being deposited singly and at different depths. In about a month, *i. e.*, the middle of July, they hatch. In other respects its habits are much as in the May beetle. In one instance two acres of plants were "irretrievably ruined." Dr. Lockwood adds that "the Goldsmith grub can be taken at any hour of the day simply by scratching the earth from around the roots of those plants whose dark, shrivelled leaves tell of the enemy's presence.

The Seventeen Year Cicada (Fig. 22, *a*, pupa; *b*, the same, showing the rent in the back out of which the adult, *c*, creeps; *d*, hole made by the ovipositor for the eggs, *e*, after Riley) in its early stages injures the roots of fruit trees by sucking the sap with its beak, while the fly in its peri odical visits deserts the oak trees, its natural food plant, and invades our orchards, causing by the deep stings of

FIG. 22.



Seventeen Year Cicada, eggs and pupa.

its large, powerful ovipositor the young twigs and small branches to wither and break off.

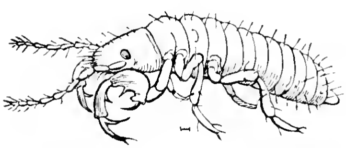
The most remarkable fact about this insect is that, while so far as we know the other species of Cicada pass but two or three years* in attaining the winged, adult state, the present one lives under ground over sixteen years, assuming towards the end of the seventeenth the winged state. We

* The European species of Cicada live three years, according to Haldeman.

have seen that the May beetle is about three years in attaining the beetle state, and the wire worm and boring beetles, such as the apple borer, may be three or four years in the larval condition, but no other insects are as yet known, with this sole remarkable exception, to be so long lived in their immature state.

The eggs of the Seventeen Year Cicada to the number of five hundred are laid in June, and about the middle of July, in the Middle States, the grubs (Fig. 23, greatly enlarged) are hatched. They escape into the ground from the twigs on the trees, and make their way to the smaller roots of the tree, burrowing a foot or two below the surface. When about to change to the winged state, they ascend to the surface, making cylindrical burrows "firmly cemented and varnished so as to be water proof."

FIG. 23.



Larva of Seventeen Year Cicada.

It should be here mentioned that certain broods of this species appear once in thirteen years, and this indicates that the ancestors of the present species went through their round of existence in two years, as in the other species. How the wonderful divergence in habits was brought about would form an exceedingly interesting subject of inquiry.

We are indebted to Dr. W. I. Burnett for an interesting suggestion concerning the chances of life in this insect, and this may give us some hints regarding the enormous waste, so to speak, of life (though after all it is an example of the economy of nature) involved in the struggle for existence among animals. Says our author, in a paper read at a meeting of the American Association for the Advancement of Science (Albany, 1851), "The female has about five hundred eggs, which, from certain relations of the other sex, which I

have made out microscopically, are probably all or nearly all fecundated. We have, then, for every two individuals which have appeared this year, a deposit of five hundred embryos for the generation to appear seventeen years hence.

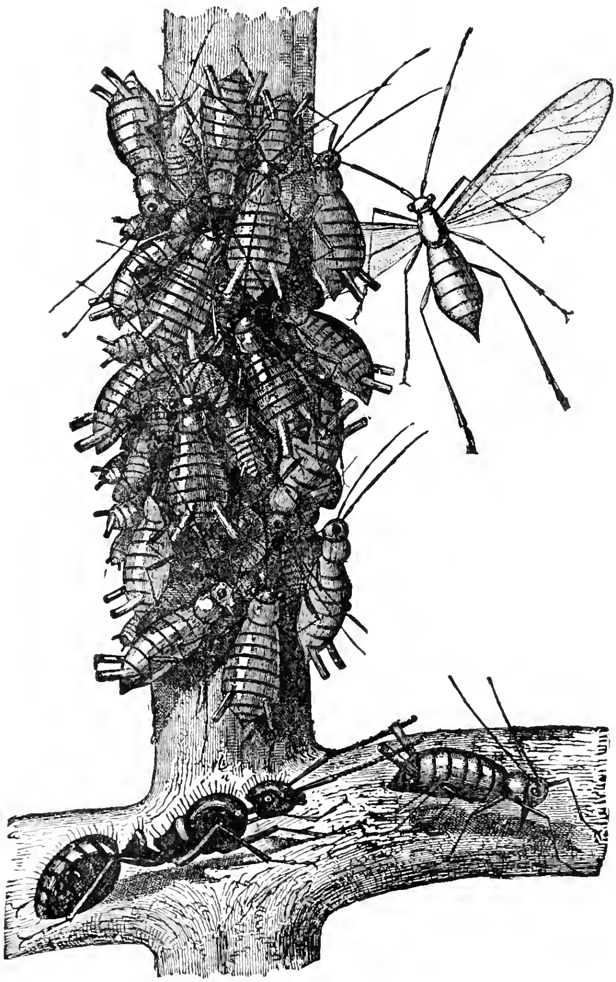
Now, from what has just been stated about the uniformity of their numbers, each time, it appears that from the liabilities of destruction during the long term of seventeen years, out of these five hundred embryos, only two appear certain of life and appearance in their perfect state, that is, just replacing the two parents. The chances of life therefore with this insect, are, in round numbers, two in five hundred. This calculation may seem strange to some, but if we reflect, it can scarcely be otherwise; for suppose the chances were double, that is, four in five hundred, then we should have at each time just double the numbers of their last time, which observation has shown to be untrue and which would augur much evil for the future condition of the vegetable world in the localities of their appearance. Even if their chances were three in five hundred, or half again the original stock, agriculturists would quickly perceive the difference.

To sum up the matter, then, we have here an insect whose economy and conditions of life are so unique that it is almost entirely isolated from human destructive agencies and which is obliged to deposit five hundred chances for the certainty of securing two. The ovaries have been formed with this capacity and the whole internal economy is of a corresponding character."

The shrill noise made by the male Cicada, "for," says Anacreon, "they all have voiceless wives," originates in two kettle-drum-like organs situated under the wings at the base of the hind body.

The Aphis (Fig. 24).—We should not be doing justice to the subject of garden pests if we omitted a special notice of that wonderful creature, the Aphis or Plant Louse. The first to appear in spring as the buds unfold, the very last to

FIG. 24.



Aphides and Ant.

desert their leafy homes in autumn, infesting every shrub, tree and herb, and not content to prey upon the leaves and bark, but even attacking the roots of annuals and trees alike, these little plagues are well nigh omnipresent.

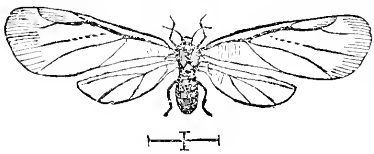
The naturalist Bonnet, as we have previously intimated, discovered in 1742 the singular mode of reproduction in these insects, by which we are enabled to account for their enormous numbers. He discovered that the summer brood of wingless individuals, or larvæ, were born of virgin mothers; that their progeny gave birth to similar aphides, and so on through the summer for nine generations, until the original maiden aphis counts her children and grand-children by millions. This large family thus launched into the world are abundantly able to provide for their own wants without the slightest anxiety to the maternal heart. They at once, on being ushered into the world, plunge their long beaks into the leaf or twig on which they crowd, and there remain through their lives, leading a gluttonous existence indeed, for when their stomachs are full they do not have to rest awhile and sharpen their appetites for the next meal, or resort to emetics, as in the palmy days of Roman epicurism, but nature has provided them with two safety valves, being two little tubes situated on the end of the body. The liquid food or sap, after passing through the alimentary canal, in part overflows through these tubes, as a sweet exudation called honey dew. It may be seen dropping on leaves, and sometimes solidifies into a solid whitish sugar.

Aphides are thus a great source of attraction to ants and other insects, which visit them for the sake of this honey. Frequently the ants will stroke them and urge them to give out their honey more rapidly, hence they seem to milk them, and the aphides are regarded as the ants' cows. Some utilitarian ants treat them as domestic cattle, herding them, and even carry this care of their flocks so far as to take them up

in their jaws and carry them to a place of safety in their nests, if danger threatens.

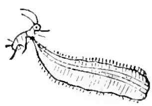
The injury done by aphides is incalculable. The Wheat aphis at certain seasons, when extremely abundant, by its punctures, and the consequent loss of sap, causes the crop to diminish, the kernel being partly shrivelled and lessened in weight. The leaves of the elm, apple tree and currant are curled up, and the tree disfigured by them, while other forms (Pemphigus, Fig. 25) produce gall-like swellings on leaves and the roots of trees. An instance where the same

FIG. 25.



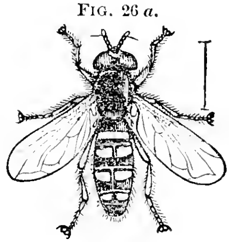
Pemphigus.

FIG. 26.



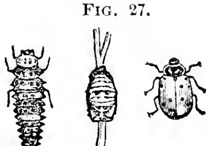
Larva of Syrphus.

FIG. 26 *a*.



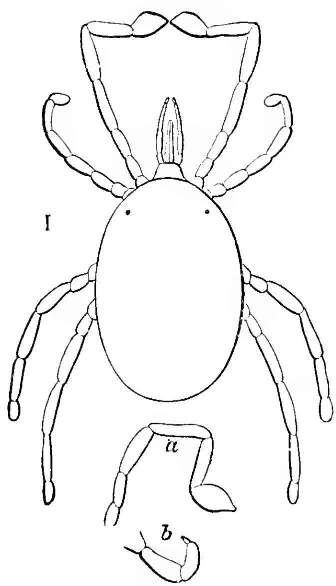
Syrphus Fly.

FIG. 27.



Lady-bird and young.

FIG. 28.



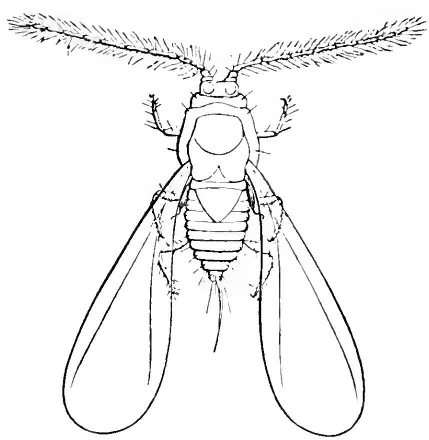
Aphis-eating Mite.

species forms galls both on the roots and leaves of the same plant, is shown in the *Phylloxera vastatrix* of the grape vine, that fearful scourge of the vineyards of Europe and America.

Fortunately they have many enemies. The maggot of the Syrphus Fly (Fig. 26; 26 *a*, the fly), Lady birds (Fig. 27, larva, pupa and beetle) prey upon them very extensively; and certain small ichneumon flies (Aphidius), as well as other insects, certain mites, such as the form here figured (*Trombidium? bulbipes*, Fig. 28), and also some birds, must diminish their numbers.

The Scale Insect.—Closely allied to the plant lice are the bark lice or scale insects, on which we will dwell for a moment. Imagine an animated oyster shell or shallow basin walking about on six slender legs, and we have the young bark louse. Let age effect its changes, the insect becoming stationary, the legs disappearing and its basin-like form glued to the bark of the tree, and it becomes still more like an oyster shell fastened to its native rock. Now compare with this bizarre form assumed by the female, the winged active male, and what a striking difference! and yet both were exactly alike in the larval state. What are the causes which have produced such a remarkable divergence between the two sexes? They are for the most part mysterious and beyond our comprehension, and yet by comparing the scale insects with other members of the family to which

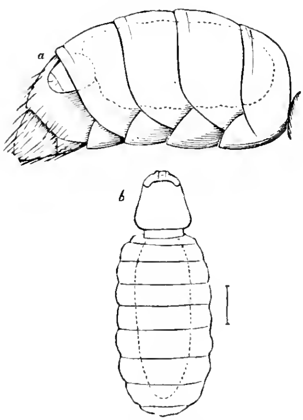
FIG. 29.



Pine Scale Insect, Male, enlarged.

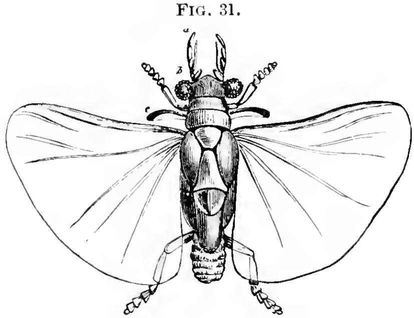
they belong, such as the mealy bug of our hot-houses or Cochineal insect of tropical countries and the Aleurodes, in which the sexual differences are less marked, and then comparing them with the aphides on the one hand, and on the other the Psylla, a member of another family closely allied, we are enabled to see that the changes in form have been undoubtedly induced by differences in habits, the kind of surface to which the scales are attached, the species of tree to which they belong, as well as to the different degree of mobility of the female; for the more she is fixed and immovable, the more active and lively is the male, just as in Stylops or bee-parasite, the female (Fig. 30) is remarkably different from the agile, volant male (Fig. 31). We may see in the aphis, where the two sexes are alike, that in their courtships the male finds its active partner in the ordinary movements of life, while since the female scale insect is immovable, its winged partner needs to be far more restless and swift in its movements than the male aphis; so that its chances of encountering its mate in the course of its travels, and thus providing for the continuance of the

FIG. 30.



Female Stylops

FIG. 31.

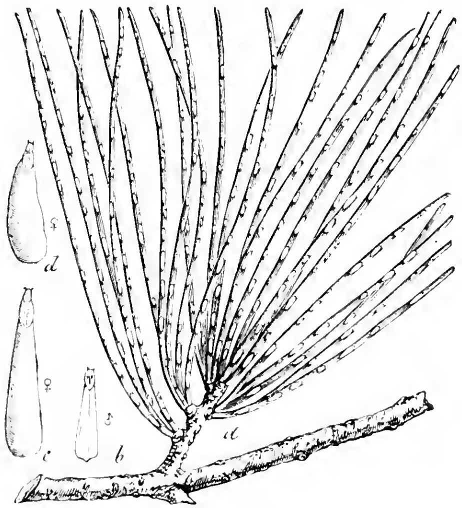


Male Stylops.

species, are greatly increased. We know from personal observation that these male scale insects do travel far from the trees on which their partners occur.

This leads us to regard this almost unnatural activity of the male scale insect as tending to prevent too close in-and-in breeding in the species. Nature in her wise and prudent forethought thus, instead of confining the sexes to one tree, so that cousins intermarry and the stock deteriorates, scat-

FIG. 32.



Pine Scale Insect.

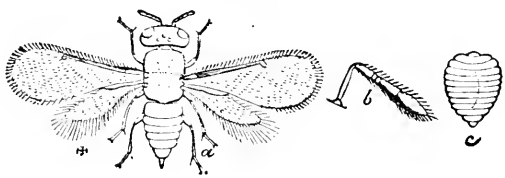
ters these two-winged atoms, bearing them along on the wings of the wind and landing them in other groves and orchards, where they may intermarry with different races, and thus the species be restrained within the proper limits. Here we have another cause by which these sexual differences may have been produced.

Any one who has noticed these female scale insects clustering on an orange or ivy or oleander leaf, knows how much their form varies with that of the surface to which they are

attached. In the Pine-leaf Scale insect (Fig. 32 ; *a*, the leaves with the scales of natural size ; *b*, male scale ; *c*, female. Fig. 29, the male greatly enlarged, after Riley) the scale marked *d* is much wider than in the one marked *c*, which lives on a narrower needle of the pine. Indeed so great is the range of variation that when we regard the larva-like females, it becomes difficult to draw the limits between the species.

Nearly every tree of the orchard and our hard wood, deciduous trees harbor one or more kinds of scale insect. The oyster shell scale insect of the apple tree is an unfailing attendant and to young trees is extremely pernicious. The orange trees of Florida have been at times grievously afflicted by another species, while our ornamental shrubs and vines,

FIG. 33.



Parasite of Scale Insect.

and hot-house plants suffer greatly from their attacks. The injury they do is the result of their vast numbers, since they cluster on the leaves and stems of plants, puncturing the skin or bark and sucking the sap flowing beneath.

Happily they have their parasites, certain exceedingly small ichneumon flies, such as *Coccophagus* and *Aphelinus* (Fig. 33 ; *b*, antennæ, *c*, larva, all greatly enlarged, after LeBaron) which prey upon them. It is not rare to find a scale insect with a large round hole in the top of its body, through which the ichneumon has escaped. Mites are also known to prey upon their eggs.

The Imported Currant Saw Fly.—This dreadful pest of currant and gooseberry bushes affords an excellent example of the mode in which an imported animal flourishes far

beyond its natural limits when introduced into a new country, where its native insect parasites and bird enemies (if such there be) cannot reduce its numbers.

It was imported from Europe into nurseries at Rochester, New York, during the year 1860. It seems since that time to have spread westward and eastward, arriving in eastern Massachusetts about 1865, and since then has been very destructive in gardens in New England, including the eastern part of Maine.

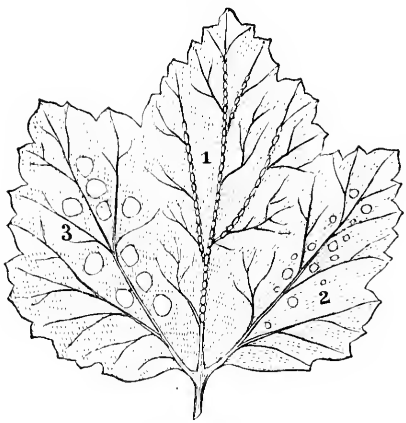
The parent of this worm is a saw fly, so named from bearing a saw-like sting, or ovipositor, with which it pierces the leaves or stalks of plants, cutting a gash, in which it deposits an egg, the egg passing out from the ovary through the oviduct, and thence through the blades of the ovipositor into the wound made in the plant. While most of the members of this family cut a gash in the leaf, into which an egg is pushed, a few, as in the present insect, simply place them on the under surface of the leaf, as seen in Fig. 34. The fly has four wings, and belongs to the group of insects (Hymenoptera) that comprises the bee, wasp and ichneumon fly.

The following account of its habits is taken from the writer's "Guide to the Study of Insects:" "There are about fifty species of Nematus in this country, of which the most injurious one, the gooseberry saw fly, has been brought from Europe. Professor Winchell, who has studied this insect in Ann Arbor, Mich., where it has been very destructive, observed the female on the 16th of June, while depositing her cylindrical, whitish and transparent eggs in regular rows along the under side of the veins of the leaves, at the rate of about one in forty-five seconds. The embryo escapes from the egg in four days. It feeds, moults and burrows into the ground within a period of eight days. It remains thirteen days in the ground, being most of the time in the pupa state, while the fly lives nine days. The first brood of worms appeared May 21st; the second brood June 25th."

Figure 34, 1, shows the eggs deposited along the under side of the midribs of the leaf; 2, the holes bored by the very young larvæ; and 3, those eaten by the larger worms.

Figure 35 (*a*, enlarged) represents the worm when fully grown. It is then cylindrical, pale green, with a pale green head, while the segment next behind the head, and the third segment from the end of the body, together with the last or anal segment, are yellow; the sixteen false or abdominal legs are also yellow; the six thoracic legs are horn-colored. The body is transversely wrinkled, especially on the back, and is slightly hairy. The eyes and jaws (mandibles) are black, and on the inner side of the edge reddish. It is about three-quarters of an inch in length.

FIG. 34.



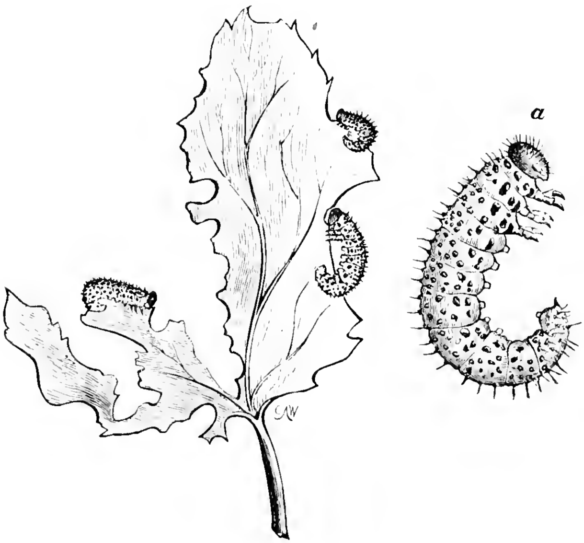
Eggs of Imported Currant Saw Fly.

Previous to the last moult, however, and before it has gained its full size, preparatory to passing into the adult or winged condition, the body is covered with black tubercles; from each of which arises a stiff black hair. There is also a supra-anal, or dorsal black patch on the last segment of the body, from which arises a pair of black spines. On the back of the false caterpillar the tubercles become smooth and transversely oval, and arranged in two regular rows. Moreover, a still more important characteristic of the worm in this state is the jet-black head, which in the fully grown insect is pale pea-green.

In the region of Salem they may be found late in May or

the first week in June feeding on the currants, and by the 8th of June they spin their cocoons, which are of silk, tough, dense, like parchment, and at first green, then becoming blackish, and covered with particles of dirt, and attached to the leaves in the breeding box. Here they remain between two or three weeks in June, the adult flies (in Salem) appearing June 25th. At nearly the same date (June 29th) the worms of the second brood were spinning their cocoons.

FIG. 35.



Larva of Imported Currant Saw Fly.

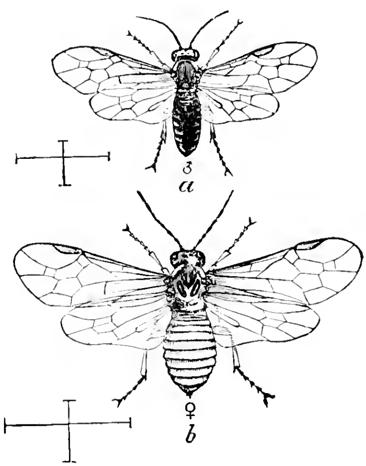
These cocoons (belonging to the second brood) remain under ground or on the leaves about the roots through the winter, the flies appearing in the spring and laying their eggs as soon as the leaves unfold.

Not having specimens of both sexes of this saw fly at hand I compile the following description (often using their own words) from Messrs. Walsh and Riley's account in the

"American Entomologist," Vol. 2, p. 16, from which these illustrations (Figs. 36 *a* and 36 *b*) are taken.

The female (Fig. 36 *b*) is a quarter of an inch long, and is of a bright honey-yellow color. The head is black, with all the parts between and below the origin of the antennæ, except the tip of the mandibles (jaws) dull honey-yellow. The antennæ are brown-black, often tinged with reddish above, except towards the base, and beneath entirely dull reddish, except the two basal joints. They are four-fifths as long as the body; the third joint, when viewed sidewise, is four times as long as wide; the third, fourth and fifth joints are equal in length, the remaining joints slowly diminishing in length. On the thorax are four conspicuous black spots, and other smaller ones. The legs are bright honey-yellow; the basal or hip joints (coxæ and trochanters) whitish, while the extreme tips of the hind shanks (tibiæ) and the whole of the hind toe-joints (tarsi) are blackish-brown. The wings are glossy, with dark veins, and expand a little over half an inch. She is known in Europe to lay eggs which have not been fertilized, and from which young caterpillars are hatched, as is sometimes the case with the silkworm and other moths, as well as other kinds of insects, including the honey bee.

FIG. 36.



Imported Currant Saw Fly.

The male (Fig. 36 *a*) is rather smaller (a fifth of an inch in length), and is black. The head is dull honey-yellow. The antennæ are brown-black, often a little reddish beneath,

except towards the base; they are as long as the body, and while longer than in the female are also somewhat flattened out. The thorax has the wing-scales and the prothorax, or collar, honey-yellow. The under side and tip of the abdomen are honey-yellow.

The injury done to currant and gooseberry bushes is very great. They strip the bushes, eating the leaves down to the leaf-stalk, myriads clustering upon the branches. The birds evidently do not feed upon them, and thus in dealing with this insect we are deprived of one of the most powerful agencies in nature for restraining a superabundance of insect life. We can scarcely realize the amount of good done to the farmer and gardener by insectivorous birds.

As this is an important and practical subject, let us digress for a moment, to notice some facts brought out by Mr. J. J. Weir, a member of the London Entomological Society, on the insects that seem distasteful to birds. He finds by caging up birds whose food is of a mixed character (purely insect-eating birds could not be kept alive in confinement), that all hairy caterpillars were uniformly uneaten. Such caterpillars are the "yellow bears" (Arctia and Spilosoma), the salt-marsh caterpillars (*Leucarctia acræa*), the caterpillar of the vaporer moth (Orgyia), and the spring larvæ of butterflies; with these may perhaps be classed the European currant saw fly. He was disposed to consider that the "flavor of these caterpillars is nauseous, and not that the mechanical troublesomeness of the hairs prevents their being eaten. Larvæ which spin webs, and are gregarious, are eaten by birds, but not with avidity; they appear very much to dislike the web sticking to their beaks, and those completely concealed in the web are left unmolested. When branches covered with the web of *Hyponomeuta evonymella* (a little moth of the Tinea family) were introduced into the aviary, those larvæ only which ventured beyond the protection of the web were eaten." "Smooth-skinned, gaily-

colored caterpillars (such as the Currant Abraxas, or span worm), which never conceal themselves, but on the contrary appear to court observation" were not touched by the birds. He states, on the other hand, that "all caterpillars whose habits are nocturnal, and are dull-colored, with fleshy bodies and smooth skins, are eaten with the greatest avidity. Every species of green caterpillar is also much relished. All Geometræ, whose larvæ resemble twigs, as they stand out from the plant on their anal prolegs, are invariably eaten." Mr. A. G. Butler of London has also found that frogs and spiders will not eat the same larvæ rejected by birds, the frogs having an especial aversion to the currant span worms (Abraxas and Halia).

The natural enemies of the Currant Saw Fly are three kinds of ichneumon flies, of which one is a minute egg-parasite. Mr. Lintner, of New York, states that of fifty eggs laid by the parent saw fly, only four or five hatched out the currant worm. We see, then, that though the birds apparently destroy none, an immense number are carried off, even before they have a chance of doing any mischief, by minute insects of their own order.

One of the best remedies next to picking them off by hand, and which is really the most practicable method of getting rid of them, is to dust powdered white hellebore over the bushes, by sprinkling it from a muslin bag tied to a stick, as it otherwise excites violent sneezing. Used in this small quantity it is not poisonous. This is the remedy used with most success in the west, and recommended by Messrs. Walsh and Riley. A solution, consisting of a pound of copperas to six gallons of water, has been used with much success. It blackens the leaves, but does not injure them permanently. Also suds made of carbolic soap is perhaps a better remedy.

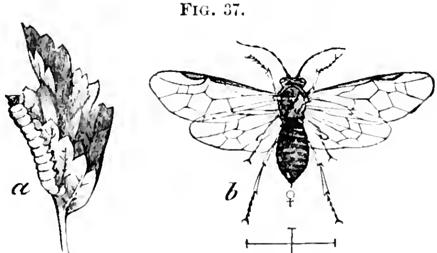
Dr. E. Worcester, of Waltham, according to the "Boston Journal of Chemistry," finds that this worm "may be fully

and almost immediately destroyed by the use of carbolate of lime. The doctor tried the powder in many instances during the past summer, and found that while it was fully as effective as hellebore, it was less disagreeable, less costly, and perfectly safe. The method of using it is to sprinkle it over the bushes as soon as the worm makes its appearance, bringing it well in contact with the leaves, and soon the insect is destroyed. It will need but two or three applications, and the work is done."

This worm attacks the gooseberry as well as the currant, though in Massachusetts its ravages have been more confined to the latter shrub. As a preventive measure against its farther spread, in buying or transporting gooseberry and currant bushes, Walsh recommends that the roots be carefully cleaned of dirt, so that the cocoons may not be carried from one garden or nursery to another.

The Native Currant Saw Fly.—As this species may be confounded with the European saw fly, though belonging to

FIG. 37.



Native Currant Saw Fly.

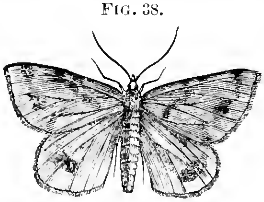
a different genus (*Pristiphora*), the following brief account of it is extracted from my "Guide to the Study of Insects."

This saw fly (Fig. 37 *a*, larva; *b*, female, from the "American Entomologist;" *P. grossulariæ* of Walsh) "is a widely diffused species in the northern and western states, and injures the currant and gooseberry. The female fly is shining black, while the head is dull yellow, and the legs are

honey-yellow, with the tips of the six tarsi, and sometimes the extreme tips of the hinder tibiæ, and of the tarsal joints, pale dusky for a quarter of their length. The wings are partly hyaline, with black veins, a honey-yellow costa, and a dusky stigma, edged with honey-yellow. The male differs a little in having black coxæ. Mr. Walsh states that the larva is a pale grass-green worm, half an inch long, with a black head, which becomes green after the last moult, but with a lateral brown stripe meeting with the opposite one on the top of the head, where it is more or less confluent; and a central brown-black spot on its face. It appears the last of June and early in July, and a second brood in August. They spin their cocoons on the bushes on which they feed, and the fly appears in two or three weeks, the specimens reared by him flying on the 26th of August." This worm may at once be distinguished from the imported currant worm by the absence of the minute black warts that cover the body of the latter. The same remedies should be used against this worm as were recommended for the imported saw fly.

The Currant Span Worm (Fig. 38, moth; Fig. 39, 1, 2, caterpillar, 3, pupa).—Many persons in speaking of the "currant worm" confound the caterpillar-like saw fly larva with the well-known geometer caterpillar, which is a native species, and was long since described by Dr. Fitch, under the name of *Abraxas ribearia*. As soon as the leaves of the currant are fairly expanded, late in May or early in June, the young caterpillars, scarcely thicker than a horse-hair, may be found eating little holes in them. In about three weeks after hatching, it becomes fully grown; it is about an inch long, and bright yellow in color, the body being covered with large black dots. The chrysalis is shining

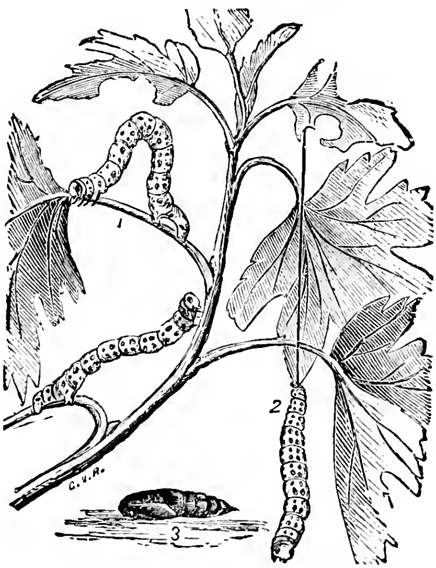
FIG. 38.



Currant Span Worm Moth.

reddish-brown, about half an inch long, and may be found late in June, either upon the ground or just under the surface. In two weeks after entering the chrysalis state the moth may be observed flying about the garden, or resting upon the leaves during cloudy weather. The moth is yellow ochreous, with dark, often nearly transparent blotches on the wings.

FIG. 39.

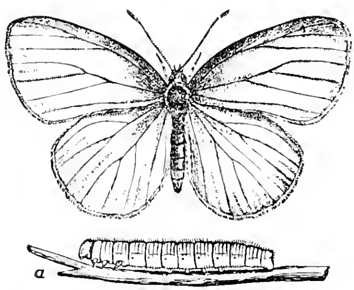


Currant Span Worm and Pupa.

It is not easily mistaken for any other moth. Mr. Riley, in an article on this insect in the "American Entomologist," states that by sprinkling powdered hellebore upon the leaves, or applying a solution of eight or twelve ounces to a bucketful of water, the caterpillars will be killed. Hand-picking assiduously followed up, and a vigorous shaking of the bushes over a sheet, or newspaper, repeated twice a day will keep this insect within moderate bounds.

The European Cabbage Butterfly.—It is interesting to compare the habits of the imported butterfly with those of our native species. We have two kinds of white Cabbage butterflies which have never done much harm to our cabbage and turnip crops. The first of these is the common white Northern Cabbage Butterfly, *Pieris oleracea* of Harris (Fig. 40, *a*, larva). We have found the larvæ of this species on turnip leaves in the middle of August, at Chamberlain farm in northern Maine. They are of a dull green, and covered with dense hairs. When about to transform they suspend themselves by the tail and a transverse loop, and their chrysalides are angular at the sides and pointed at both ends (Harris). The butterfly is white, with the wings dusky next the body, the tips of the fore wings are yellowish beneath, and the hind wings are straw-colored beneath. The yellowish, pear-shaped, longitudinally ribbed eggs are laid three or four on a single leaf. In a week or ten days the larvæ are hatched. They live three weeks before becoming full-fed. The chrysalis state lasts from ten to twelve days. There is an early summer (May) brood and a late summer (July) brood of butterflies.

FIG. 40.



Native Cabbage Butterfly.

While this kind feeds on the leaves of the cabbage and turnip, the Southern Cabbage Butterfly (*Pieris Protodice*), when in the caterpillar state, feeds on the outer leaves of the cabbage plant. It is often destructive in market gardens in the middle and southern states. But the injury done by our aboriginal butterflies is slight indeed compared with that resulting from the European species, which is usually

unchecked by its ichneumon parasites or by birds, which are preserved in Europe, where with us they are either brutally murdered, or neglected if allowed to live.

The European Cabbage butterfly (*Pieris rapæ* Schrank) is, however, a hundred fold more formidable insect, as it is fearfully abundant where it occurs, and the caterpillar feeds inside of the cabbage head when forming.

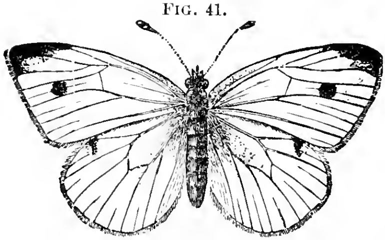
It was introduced from Europe to Quebec about the year 1857, having been captured in 1859 by Mr. Bowles, of that city. It rapidly spread into New England along the different railroads leading in from Canada, and is now common about Boston and New York and has reached Washington. About Quebec it annually destroys $250,000 worth of cabbages, according to the Abbé Provancher. It is evident that, in this newly arrived insect, we have another formidable pest added to our list of imported insects.

The male butterfly (Fig. 41) is white, with the tips of the fore wings black, dusted with white, while on the fore wings is a single, and in the female (Fig. 42) there are two large black spots, situated two-thirds of the distance from the base to the outer edge of the wing. It expands about two inches. The female lays her eggs singly on the under side of the leaves. The caterpillar (Fig. 43, *a*) is green, and so densely clothed with minute hairs as to be velvety; it has a yellowish stripe down the back, and another along each side, the belly being of a paler, brighter green; it is often more than an inch long, and about as thick as a large crow-quill. It changes in September under some board or stone, to a chrysalis, suspended by a thread spun over the back, as shown at Fig. 43, *b*. It is of a pale flesh-brown color, freckled with black. It does not appear to have been very destructive in Europe, but, like other introduced species, it suddenly becomes a fearful scourge. The best remedies are evidently hand-picking when the caterpillars can be seen, and the capture of the butterflies by means of a light gauze

net mounted on a wire ring a foot in diameter, and attached to a short pole. Affected cabbage heads should be carefully examined, and if much infested by worms, be burnt, for if they are suffered to lie about the garden after being pulled up, the caterpillars will attack the other plants.

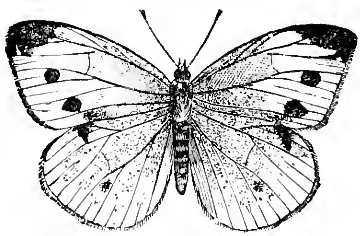
A correspondent of the "American Agriculturist" for November, 1870, states that "it is estimated that the loss from this insect will, in the vicinity of New York [city]

FIG. 41.



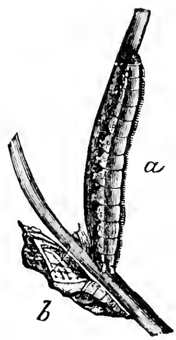
Imported Cabbage Butterfly, male.

FIG. 42.



Imported Cabbage Butterfly, female.

FIG. 43.



Caterpillar and Chrysalis.

alone, exceed half a million of dollars; and already the price of cabbages has advanced." He says that Mr. Quinn, the owner of a large plantation, "has found carbolic powder, superphosphate and lime together, to destroy them. The carbolic powder appears to be sawdust impregnated with carbolic acid. Salt has been recommended, but Mr. Quinn did not find dry salt efficacious, though lime has been reported by others as useful."

Mr. C. S. Minot, in an interesting article entitled "Cabbage Butterflies," in the "American Entomologist," vol. 2, strongly recommends destroying the chrysalis, which may be found under chips, boards, stones, etc., and advises that boards, raised two inches above the surface of the ground, be placed among the plants to attract the caterpillars when about to change to a chrysalis.

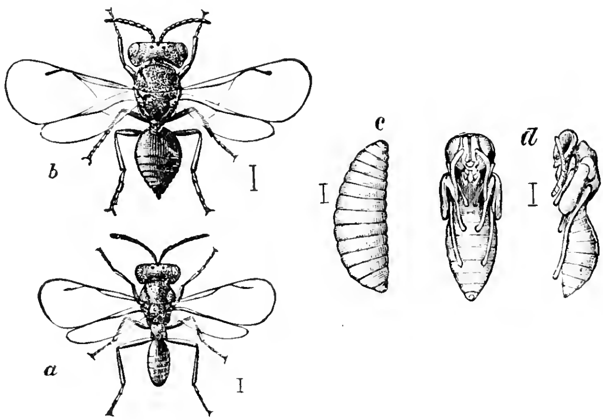
Mr. Curtis has described and figured several parasites of the three species of cabbage butterflies found in England, and he shows how thoroughly they keep in check these troublesome worms. Certain minute ichneumon flies (Chalcids) lay their eggs in those of the butterflies. Another Chalcid fly (*Pteromalus brassicæ*) lays its eggs on the outside of the chrysalis of the White Cabbage Butterfly (*Pieris brassicæ*), and sometimes two or three hundred of the little Chalcid maggots have been found living riotously within a single chrysalis. They turn into minute brilliant flies, which multiply in excessive quantities. Mr. Curtis remarks that "some species of this extensive genus (*Pteromalus*), probably comprising nearly one thousand species (!) swarm even in our houses, especially in the country, where in October and November I have seen immense numbers inside of the windows, and I believe that they hibernate behind the shutters, in the curtains, etc."

Fortunately for the prospects of American gardeners, we have a parasite (Fig. 44 *a*, male; *b*, female; *c*, larva; *d*, pupa) which already carries off large numbers of the caterpillar. Lately, in the middle of September, Mr. F. W. Putnam handed me one hundred and ten chrysalides of the butterfly, all but two of which were infested by these parasites in both the larval and pupa states; while from other chrysalides the adult Chalcid flies were emerging. They continued to emerge until late in the autumn. The infested chrysalides of the butterfly could be easily distinguished by the livid and otherwise discolored and diseased appearance of the body,

while those unattacked had preserved their fresh color, and the tail moved about readily, the diseased ones becoming stiff and more or less dried. Mr. Putnam thinks that at least two-thirds of the chrysalides of this butterfly, hundreds of which had in the early autumn suspended themselves about his house and fences, had been attacked by these useful allies.

On opening the body of the infested chrysalides I found about thirty parasites in different stages of growth, in one case thirty-two, in another only twelve. We can readily see

FIG. 44.



Parasite of Cabbage Butterfly

how efficient these minute insects become in reducing the numbers of their hosts. A large proportion of the Pteromali undoubtedly winter over in the body of the chrysalis, the adult insects appearing in the spring. In England Mr. Curtis found the fly in June, so that evidently there is an autumn and spring brood of Chalcid flies.

The male of this Pteromalus is a beautiful pale-green fly, with the body finely punctured and emitting metallic tints; the abdomen, or hind body, is flat, in dried specimens with

a deep crease along the middle of the upper side, and it is much lighter in color and with more decided metallic reflections than on the rest of the body. The antennæ are honey-yellow, with narrow black wings. The legs are pale honey-yellow. It is from one-twelfth to one-tenth of an inch in length.

The body of the female, which would be thought at first to be an entirely different kind of insect, is much stouter, broader, with a broader oval abdomen, ending in a very short ovipositor, while the underside of the body near the base has a large conical projection. It is much duller green than the male, and the body is more coarsely punctured. The scutellum of the metathorax is regularly convex, not keeled, in both sexes. The antennæ are brown, and the legs brown, becoming pale towards the ends, the ends of the femora (thighs) being pale; the tibiæ are pale-brown in the middle, much paler at each end, while the tarsi are whitish, though the tip of the last joint is dark. It is from a line to a line and a third in length. It differs from Harris' *Pteromalus vanessæ* in the little piece known as the scutellum of the metathorax being smooth, not keeled, and by its darker legs.

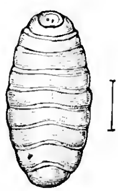
The larva is a little white maggot about a sixth (·17) of an inch in length. The body consists of thirteen segments, exclusive of the head, and is cylindrical, tapering rapidly towards the head, while the end of the body is acutely pointed. The chrysalis is whitish, the limbs being folded along the under side of the body, the antennæ reaching to the end of the wings; the second pair of legs reaching half-way between the end of the wings and end of abdomen; while the tips of the third pair of feet reach half-way between the second pair of feet and the end of the abdomen. It is from a line to a line and a third in length.

This invaluable ally of the gardener is one of the chalcid family of Hymenoptera, and was long ago described by Linnæus under the name of *Pteromalus puparum*, from the

fact that it inhabited the pupæ, or chrysalides, of butterflies. This insect has been known to inhabit this country since 1844, as there are specimens in the British Museum taken in Hudson's Bay Territory in that year; so that it is probably indigenous to both countries, while its present host in North America is the imported cabbage butterfly introduced in 1857.

I have found that another parasite attacks this insect, as the larva of a species of Tachina (Fig. 45) occurred in the body of a caterpillar. Doubtless others will eventually be found to take up their abode in the body of this insect. It would be interesting to learn whether the birds prey upon the butterfly or caterpillar, and whether they assist in reducing the number of these pests. We can but hope that the present enormous numbers of these worms will, as soon as the insect becomes fully domesticated, be held in check by the united efforts of gardeners and the natural enemies of the insect.

FIG. 45.



Tachina larva.

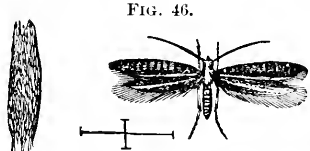
As the worm eats the interior of the cabbage or cauliflower it is difficult to deal with. Something can be done by showering the heads with a solution of carbolic acid or strong soap suds, but it is better to employ hand picking, and when the plants are hopelessly infested to throw them on a hot fire. If fed to animals the worms will manage somehow to escape.

The Cabbage Web-moth.—Another destructive insect, which is almost cosmopolitan in its distribution, is a little green caterpillar, which at times so abounds on the outer leaves as to threaten the destruction of whole fields of cabbages. It is most abundant in a warm and unusually dry season. Dr. Fitch was the first to observe it in Illinois during the year 1855. He named it *Cerostoma brassicella*, but it is undoubtedly the well known European *Plutella xylostella*, and first described by Linnæus. Though the insect has been

observed in this country only late in the summer and in September, when the cabbages have headed, yet these worms, as Dr. Fitch suggests, probably belong to a second brood. Mr. H. T. Stainton, in his excellent "Manual of British Butterflies and Moths," states that the moths fly in May and August, while the caterpillars appear in June, July, and a second brood again in September. Dr. Fitch suspects that the first brood of caterpillars may feed on the young cabbage plants in early summer, and thus do more mischief than in the autumn, when the heads are fully formed.

The caterpillar is a little pale green worm, with small, stiff, dark hairs scattered over the body; it is a quarter of an inch long. When about to transform it spins a beautiful open net-work of white silken threads, forming a cocoon (Fig. 46*) open one at end; it is a third of an inch long.

FIG. 46.



a

Cabbage Web-moth and cocoon.

The moth itself (Fig. 46 *a*) is pale gray, with the head, palpi and antennæ white, but the latter are ringed alternately with white and gray on the outer half. The rest of the body is gray, except on the under side, and on the middle of the thorax, where there is a broad, white, longitudinal band, which when the wings are folded is continuous with the white band along the inner side of the wings. The two front pair of legs are gray, with the tarsal joints ringed narrowly with white; the hind legs are whitish and hairy. The fore wings are gray, with a conspicuous, broad, longitudinal, white band along the inner edge, and extending to the outer third of the wing; this band sends out three teeth towards the middle of the wing, the third tooth being at the end of the band. There is a row of dark dots

*This and figure 44 are from my "Report on the Injurious Insects of Massachusetts," and are kindly loaned by Mr. C. L. Flint, Secretary of the Massachusetts Board of Agriculture.

along the outer edge of the stripe; a row of blackish dots along a pale shade just outside of the front edge of the wing, and two rows of blackish dots diverging upon the tip or apex of the wing. The fringe is marked with a few dark spots. The middle of the wing next the white band is darker than the front edge, while a faint yellowish shade runs along the middle of the outer half of the wing towards the tip, enclosing a few black dots. It expands a little over half an inch.

Should young plants be attacked by the worms, the best remedy would be to shower them with soapsuds. For the autumnal brood of worms the plants should be plentifully showered; and if this is not efficacious, the worms should be picked off by hand, the cocoons especially.

The Garden Leaf Roller.—One of the most intelligent and industrious of our garden pests is the leaf-rolling caterpillar, which as soon as the leaves unfold in the spring begins to draw them together in an ingenious manner by silken threads, in order to make a rude sort of domicile where it may live hidden from the sharp eyes of its feathered and insect enemies. By the first of June its presence in the terminal shoots of the apple, the rose, and other shrubs, together with the strawberry, may be detected by the crumpled and distorted mass of leaves at the end of the shoot, or, if the strawberry plant, by the leaves being sewed together in a tangled head.

How is the following problem in mechanics to be solved? How does the tiny worm pull the leaves together, and sew them into a rude sort of tube or tent? The little creature begins by spinning a thread and attaching one end to some fixed point, and then attaching the other to the loose leaf. By means of the powerful muscular movements of the front part of the body, and like a sailor, except that our caterpillar uses its teeth (it is doubtful if the fore legs assist in the operation) it hauls away on the rope of silk, slowly pulling it up to the desired point, where it is held in place by a new

and shorter thread. Finally, after much labor, the young caterpillar (for it begins its work soon after hatching from the egg) spins a number of threads, each of which adds new strength to the tubular structure, until a tent arises — the whole the work of perhaps but a few minutes. In this tent it resides, enlarging it as its body grows, and eating out the interior, adding new stores of food by sewing new leaves to the outside of the tent, until, when about to pass into the chrysalis state, it stops eating. It does not now desert its home. Its tent serves it as a rude cocoon, the caterpillar having previously lined it with silk, and we often find the end of the chrysalis protruding out of the door of the tent after the moth has flown away.

FIG. 47.

Leaf-roller.

This species of leaf-roller, called *Lozotænia rosaceana* by Dr. Harris (Fig. 47, enlarged twice), is rather large compared with others of its family, its body rather plump and pale livid green, its head is black, as is also the ring following, while the other segments are transversely wrinkled above, with a few scattered fine hairs. The moth itself usually appears about the last of June. From its eggs laid at this time a new brood of worms appear in August. The pupa or chrysalis is pointed on the top of the head, and on the hinder edge of each abdominal ring are two rows of spines. The moth is pale brown, with two broad oblique darker reddish brown bands across the fore wings, and a triangular spot of the same color near the tip. The hind wings are ochreous yellow. The wings expand about an inch, and the caterpillar is a little less than an inch long. There are many other leaf-rolling caterpillars which roll up leaves much more perfectly than the Garden Leaf-roller. No one has described their mode of building their tubular houses better than the celebrated French philosopher and naturalist, Réaumur. We may find on some of our trees leaves rolled up much like those here figured from Réau-

mur's work entitled "*Mémoires pour servir a l'Histoire Naturelle des Insects*," and which are copied from Figuier's work "The Insect World."

Figure 48 represents an oak leaf which has been partially

FIG. 48.

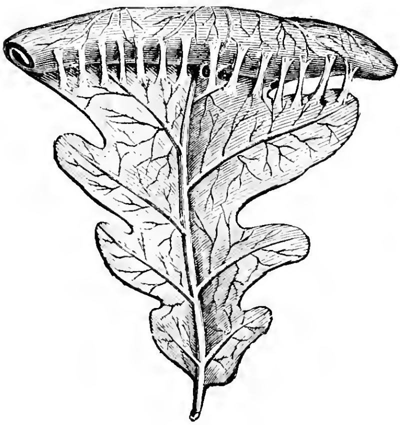
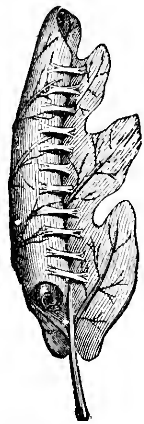


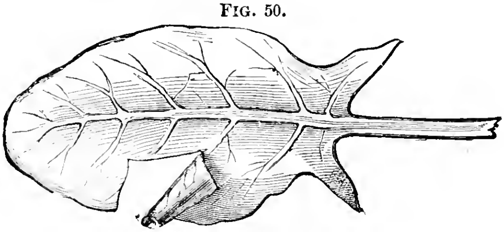
FIG. 49.



Oak leaf rolled perpendicularly and sidewise.

rolled up transversely. We can see with what care the leaf has been rolled up, and how at each step the roll has been secured by bundles of silken strands. A similar roll is seen

FIG. 50.



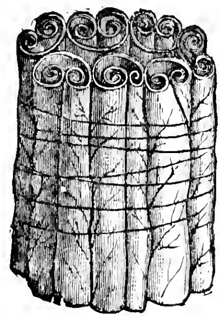
Sorrel leaf cut by a caterpillar.

at figure 49, where the leaf has been rolled sidewise or longitudinally to the leaf, with the same painstaking. Another species Réaumur found to roll a portion of a sorrel leaf, cut-

ting it away from the side of the leaf, and then deftly rolling it up into a slender cone, which stands up nearly on its base

FIG. 51.

FIG. 52.



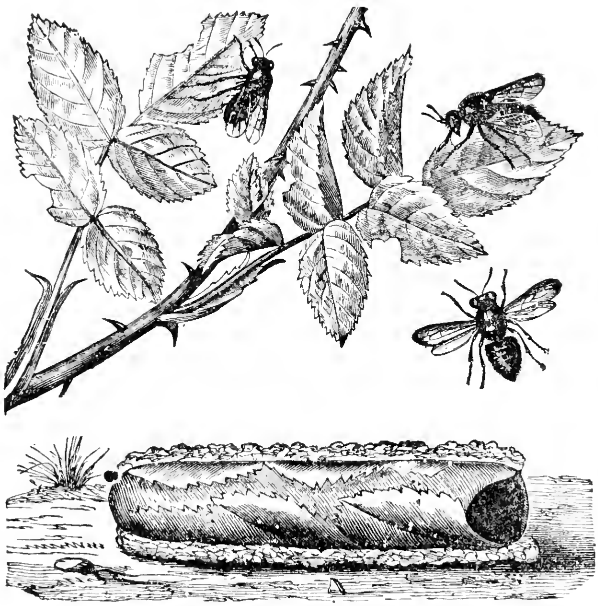
Willow leaves rolled by a caterpillar; and section.

(Fig. 50). An example of a less perfect roll, and one intermediate in perfection between the foregoing nests and the tent of the common garden Tortrix, is shown in the accompanying figure (51) of a number of willow leaves rolled up by a caterpillar, while figure 52 gives a transverse section of the same compound roll with the outer threads binding the simple rolls into a bundle. Our garden leaf-roller can

be best subdued by hand picking. It is easy to detect the tents, and a simple matter to remove the worm and crush it under foot.

The Leaf Cutter Bee.—The leaves of the rose bushes in the garden are sometimes strangely cut into, as if some fairy had overnight deftly cut them with her wanton scissors. To

FIG. 53.



The Leaf Cutter Bee and nest.

many this fact is a sore puzzle. It is due to a leaf-roller of quite a different sort from any we have before considered. The figure (53 after Figuier) represents the Leaf Cutter Bee cutting out a circular piece of leaf with her seissors-like jaws, while the nest, composed of numerous pieces variously folded and pressed together, attests her wonderful skill and forethought.

3. Relations of Insects to Man.

IN continuing these half-hour talks about insects, some remarks upon the more direct relations of these little beings to human interests may not be inappropriate. We may, from our moral and intellectual heights, look down upon the lower world of insects as did the gods and demi-gods of old from Olympus upon their half-brothers and cousins-german on the plains below. For physically are we not related to the insects? Remotely, it is true, but still we have perhaps branched off from a common stock, the starting point some monad. Our blood differs in quality and not in kind; our muscles are but repetitions in structure of the flesh of insects; and finally, an insect at the outset is but a drop of oil and albumen or protoplasm, and from what else does man originate? Allied as he is also to the beasts and lower animals in being at times under the control of fierce passions and animal propensities, while morally and intellectually the noblest work of the Creator, one effect of the recent advances in the science of man, which indicate that his animal origin is a matter of strong probability, will be to draw out his interest in the humbler creatures, to lead him to deal with them more sympathetically, to love his domesticated animals more wisely and truly; while he may not the less, by worship of his Creator and work for humanity, strengthen the diviner impulses of his nature.

> "He prayeth well, who loveth well
> Both man and bird and beast."

Every true naturalist is an *ex-officio* member of the "Society for the Prevention of Cruelty to Animals." He will not beat his horse or dog any more than his own children. Rather

will he endeavor to train them by the power of kindness than by the force of blows.

So in the dealings of civilized with savage man; the legitimate results of a proper study of anthropology, or the science of man, while teaching us that there are different grades of intellect and moral sense in the different races of man, as in the members of our own families, where each may require a different mode of education though all are equally loved by their parents, will lead us to observe the primary law of international behavior—the law of love. Each may require a different mode of treatment, while all must be regarded as men and brothers.

Though one race under a favoring heaven and superior mental organization stands superior to another, yet, if many naturalists are right, all have had a common monkey origin; and the European or American of to-day need not despise his Bushman or Australian brother, who is perhaps but a few removes nearer his simian ancestors than himself.

So all the animal creation is of a piece; part and parcel of one grand Divine plan. Some philosophers and theologians even ascribe immortality to the animals, and believe that in the hereafter we shall hear the song of the mosquito, the hum of the bee, and the shrill rolling drum-beat of the cicada.

Insects are related to us in a thousand ways, and somehow, either by themselves or through their products, they are, more than we should at first imagine, constantly in our daily thoughts. Beau Brummel's cravat, which historians tell us absorbed no small proportion of his thoughts in his waking moments, was spun by a silkworm. A spider's web, tradition says, saved King Robert Bruce in his sleep. Thousands of people in the East are dependent for life on locusts and wild honey. Is the potato beetle an unimportant personage in the west? And in the south are not hundreds of thousands of dollars' worth of cotton annually devoured by

the army worm? In the New England states is not the face of nature almost transformed by the ravages of the canker worm? How life to many would be glorified, and this world seem a brighter one, if the flea, the louse and the bed-bug were removed from its surface!

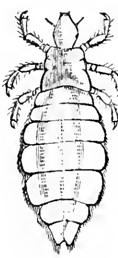
How much difference would it make to the world of insects were man to be blotted out of existence? We imagine the insects would look with as much indifference upon his removal as we in turn regard the demise of a mosquito. Have not, through the ages past, from the time when the first grasshopper chirped upon a tree fern's leaf in the Devonian forests of New Brunswick, millions of species of insects had their day and died, with no human being to witness them? Imagine the eons and eons of measured eternity through which by day and night the busy hum of insect life has risen and fallen with no human ear to listen. But on the other hand blot out those busy servants of ours, the bees; the myriads of insects that aid in fertilizing our vegetables and fruit trees; the silkworm, whose products form so large an item in the commercial greatness of the East and of Southern Europe; the lac and dye insects; those that produce galls for making ink; the myriads of grubs and flies that act as scavengers, and purify the air, saving us from pestilence; all working so quietly and effectively that few appreciate how much we owe to them — blot out all of these and the world would be a poor home for its owner, man. He would be forced then, if never before, to appreciate the place of man in creation, and would be taught that as an animal his life touches at many points the lives and interests of the humble creatures about him.

We naturally divide insects into friends and foes, but our senses are still quite uninstructed in distinguishing them, and few but the trained entomologist can go into the field or garden and mark this insect as a true friend, and that, so much like the other that ordinary eyes cannot

distinguish them apart, as an enemy of our comfort or crops.

Moreover there are insects which are friendly in but a Pickwickian sense. There are certain parasitic insects that stick to us closer than a brother, and yet with the moral qualities of fiends. Man is a sort of treasury or bank to these creatures — and they are happily few in number — who "draw" upon him not only "at sight," but who "go it blind." And when through carelessness or idleness the bank is too attractive and liberal in its discounts, the audacious vermin congregate in teeming hosts, and make "a run" upon it. Parasitic insects seem in many cases to be actually blind through avarice, as amaurosis is not an uncommon affection among articulated parasites. It would seem as if the gods struck blind all such beings for their greed in sucking our blood.

FIG. 54.

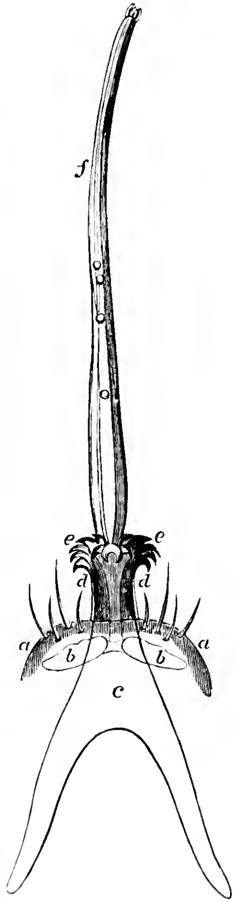


Louse.

There is the louse (Fig. 54), the most intimate of these friends, forsooth, of ours. Ugly and repulsive in itself, it is tenfold more so in its associations. Though its legs are well developed, the beak wonderfully adapted for its use, yet it lives in a Stygian twilight, its eyes reduced to a simple point, a little depression on the side of its head forming but a single isolated facet, the simplest kind of eye, when there are 25,088 such facets in the eye of a certain small beetle (Mordella) and 4000 in that of the house fly, whose head is all eyes. If we look at the beak of the louse (Fig. 55) we shall at once perceive that the creature does not bite, but that it in reality sucks our blood; so the mosquito introduces its blade-like jaws and sucks our blood. It is incorrect to say that a mosquito bites. Those organs that in allied insects are jaws, in the lice lose their biting function and are converted into a fleshy extensible tube, the true jaws forming ribbon-like bands strengthening the tube.

When looking about for a weak place in the skin of his host the creature alights upon a sweat pore. Into this he plunges his sucker, and anchors it there by a number of hooks (Fig. 55, *ee*). After they have firmly grasped the surrounding flesh the first pair of bristles (the real mandibles transformed) are protruded (we are quoting Prof. Schiödte here almost word for word, as given in the "American Naturalist," vol. iv, p. 86). These bristles are towards their points united by a membrane so as to form a closed tube. When the whole instrument is exserted, we perceive a long, membranous, flexible tube (the portion from *e–f* and including the end) hanging down from the under lip (labium), and along the walls of this tube the bristle-like jaws in the form of narrow bands of chitine.

FIG. 55.



Mouth of a Louse.

In this way, says Schiödte, the sucking tube can be made longer or shorter as required, and easily adjusted to the thickness of the skin in the particular place where the animal is sucking, whereby access to the capillary system is secured at any part of the body. "It is apparent from the whole structure of the instrument, that it is by no means calculated for being used as a sting, but is rather to be compared to a delicate elastic probe, in the use of which the terminal lobes probably serve as feelers. As soon as the capillary system is reached, the blood will at once ascend into the narrow tube, after

which the current is continued with increasing rapidity by means of the pulsation of the pumping ventricle and the powerful peristaltic movement of the digestive tube." Fig. 55 shows this tube and adjacent parts of the head magnified one hundred and sixty times; *aa* the end of the head; *bb* the chitinous band, and *c* the base of the under lip; *d* the under lip protruded, with the hooks *ee*; and *f* the sucking tube, with a few blood disks passing through it.

How a louse breathes is perhaps as practical a question as how it bites. All insects inhale air through a row of holes (stigmata) in the side of the body, which connect by a series of tubes (tracheæ) within, ramifying throughout the body; no air is taken in through the mouth. Now grease and oil, when in contact with the sides of the body, tend to close up these breathing holes, and then the creature suffocates. Thus oil or pomatum is an antidote. A word to the wise is sufficient.

Not only personally, but also indirectly, through those kinds which swarm on his domestic fowls and quadrupeds, is man affected by these creatures. Those species which live for the most part on birds have true jaws, enabling them to nibble and thus irritate the skin of their host.

While we are upon this harassing theme we should not pass over that kindred subject the bed-bug. This insect, with a body so flat that an ordinary punch with the thumb only seems to tickle it, seems preordained for a life in cracks and crannies. First noticed in literature by Aristotle, it was also mentioned by Dioscorides and Pliny. It was first met with in Germany in the eleventh or twelfth century, and was mentioned as an English insect by Mouffet in 1503. It is possible that its original haunt was the nests of doves and swallows; and the most effective way, should it seem desirable to ensure an abundant harvest of these pests, is to keep a number of these birds about our houses. Whether it actually lives under the feathers of doves or not could be

easily ascertained. If so, then they are as truly bird parasites as the lice, to which they are (especially when young) not remotely allied in form and structure. That they (or a closely allied species) sometimes swarm in the nests of swallows, we have been informed by a gentleman in Iowa, who found a nest of swallows, as stated in the "Guide to the Study of Insects," on the outside of a court house which swarmed with bed-bugs; and they were not confined to the nest, but flocked in the apartments, "frequently serving well pointed bills of ejectment against the legal gentlemen within." They continued to trouble the occupants year after year until the stream of hemipterous life was traced to its fountain head, the swallows' nests. The opinion that the bed-bug originally lived under the feathers of house-haunting semi-domestic birds is strengthened by the fact that a European species of Cimex lives on the body of the swallow, another on the bat, while a third is found in pigeon houses and is named from that fact the Cimex of dove-cotes (*Cimex columbarius*). We have in this country a flat bodied red bug, closely allied to the true bed-bug, but its habits are quite unknown.

We need not tell harrowing tales of the disgusting habits of this scourge, for are there not fresh experiences in the minds of those who travel most in the more unsettled portions of our country, as well as the other parts of the globe? A word or two on some less known traits of this creature may give some useful hints in dealing with it. The parent lays white oval eggs, and when the young bug is fully formed within it escapes by pushing off the end like a lid, as one pushes up a trap door. The young are at first whitish and transparent, the stomach being visible, usually red from being filled with blood, and at this time it bears a striking resemblance to a louse. Westwood says that it is eleven weeks in attaining its full size. The adult is hard lived in a double sense; its tenacity of life is only equalled by its viciousness

The Swedish Count Degeer, in his classic *Mémoires*, published a century ago, says that he kept full sized individuals in a sealed bottle for more than a year without food. Dr. Landois has recently ascertained how these insects are enabled to fast so long. He observed that, as in the flea and louse, the blood drawn in from their victims, collecting in the small intestine, loses its cells and forms a blackish mass, which remains for months unaltered. "Thus after the bug has fully gorged itself, it has within its small intestine a reservoir on which it may live a long time."

But happily, though few may be aware of it, the bed-bug has a natural enemy, the cockroach, whose "mission" it

FIG. 56.

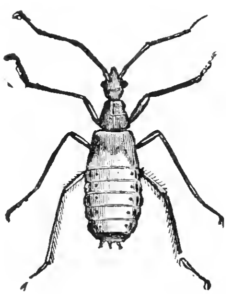
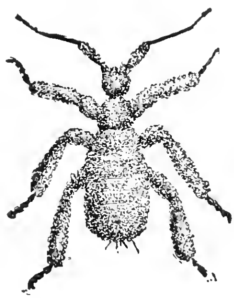


FIG. 57.



Reduvius, pupa and young.

seems to be to keep this and other insects in check. What, then, if the cockroach nibbles our towels and clothes occasionally when driven through stress of hunger? The cockroach is particularly valuable on ship-board by reason of its insectivorous habits. The Reduvius (Fig. 56, pupa) is also said to prey upon the bed-bug. Degeer tells us that the wingless young (Fig. 57) have the instinct to envelop themselves in a thick coating of particles of dust, and "so completely," adds Westwood, "do they exercise this habit that a specimen shut up by M. Brullé, and which had undergone one of its moultings during its imprisonment,

divested its old skin of its coat of dust, in order to recover itself therewith."

Does the bed-bug poison us when it bites? So we may ask whether the flea, mosquito and black fly, convey a drop of poison into the punctured wound they make. This is a disputed point. Dr. Landois, however, the latest writer on this subject, thinks that "when the creature is sucking, a part of the salivary fluid can easily pass into the wound, and it is not unlikely that the red stains that we often see appearing after a sting on the hands of sensitive persons originate from the saliva which flows into the wound and acts as a poison." Other hemipterous insects, he adds, are dreaded on account of their sting. "*Cimex nemorum*, according to Kirby, stings as powerfully as a wasp, and *Notonecta glauca* stings with a burning sensation." St. Pierre found in the Mauritius bugs whose sting was as poisonous as that of a scorpion, giving rise to swellings the size of a dove's egg and which lasted for five days.

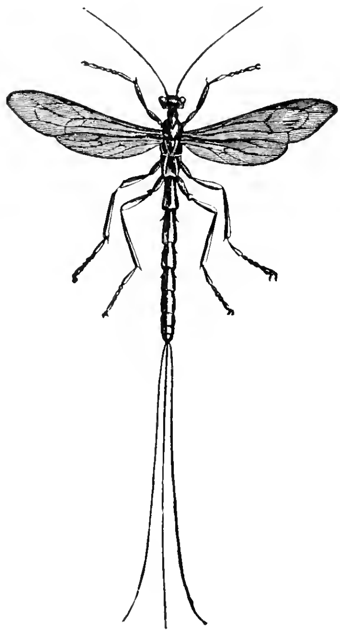
Another sort of bug is sometimes, according to Mr. Riley, found in beds in the western states. It is the *Conorhinus sanguisuga*. It is much larger than the common bed-bug, and its bite is much more painful. It belongs to quite a different group of hemipterous insects and is allied to the Reduvius of which we have spoken.

Passing by the flea and the itch mites, which end the list of human parasites, and whose habits and appearance are so well known, we will dwell for a few moments on the poisonous insects which trouble man. The poison of all insects, judging from the chemical composition of that of a few kinds which has been analyzed, is alkaline in its nature, and has for its main ingredient formic acid, a substance peculiar to the secretions of insects.

The sting of the bee is simply a modified form of the ovipositor of the ichneumon fly (Fig. 58, from Figuier) and the saw of the saw fly. It is composed of three pairs of

slender blades; the innermost, forming the sting proper, being barbed at the end so that when darted into the flesh of its victim it often remains and the bee stings but once. The poison gland or bag empties into the sting, the poisonous fluid being forced by the pressure of the walls of the body upon the sac, there being apparently no special muscles

FIG. 58.



Ichneumon Fly.

adapted for the purpose. The sting of the wasp is like that of the bee. The celebrated Réaumur, as quoted by M. Tandon, thus discourses on the effect of the sting of wasps on himself and his servant: "Being stung by a wasp, I thought I might gain something from his infliction by bearing it with a good grace. I allowed the animal to wound

me at his leisure; when he had withdrawn his sting of his own accord I irritated and placed him on the hand of a domestic, who was not expecting to be stung, but the wound did not cause him much pain. I then made the wasp sting me a second time, when I scarcely felt it. The poisonous fluid was nearly exhausted by the former experiments, and I could not induce the wasp to make a fourth wound. This experiment and others, which people will probably not care to repeat, have taught me that where the animals are undisturbed the sting is never left in the wound. The sting is flexible, and is not driven straight in, but forms a curved or zigzag wound. If the insect is compelled to withdraw it suddenly, the friction is sufficient to retain the sting, which is somewhat hooked, and tears it off. On the other hand, if the animal is not disturbed, it withdraws the sting gradually."

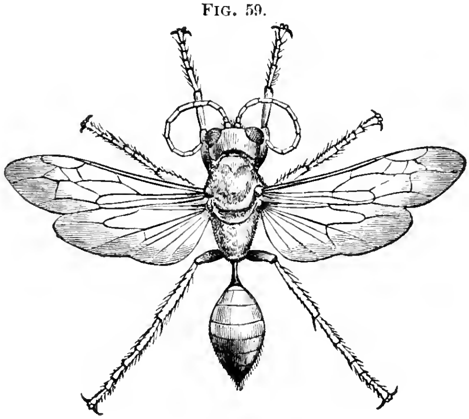
There is quite a difference in the poisonous qualities of different kinds of bees as well as wasps, and in the size and strength of the sting. We have been used to catching wild bees and wasps, without being stung, by firmly grasping the hind body or abdomen with our fingers, rendering the sting powerless.

How useful the sting is to bees is shown in the honey bee, which uses it as a weapon of offence as well as defence, in stinging the caterpillars of the bee moth, which are careful to run concealed galleries in the wax to avoid their thrusts; and in killing the drones.

The term waspish is derived from the irritable nature of those insects, whose brusque and defiant manners are doubtless in large part due to the consciousness that they are well armed. But in many wasps the sting is not only a weapon of defence, but of prime importance in maintaining the existence of their young and consequently of the life of the species. We have spent hours watching a Sphex wasp (*Sphex ichneumonea*, Fig. 59), a large rust-red species

covered with dense golden hairs, busily engaged in digging its hole in a gravelly walk. Away it worked in a lusty, hearty manner, literally tooth and nail, removing the larger bits of gravel with its large curved sickle-like jaws; and as it finally tunnelled itself out of sight, it would often back up out of its hole, and scratch and shovel the dirt out with its fore and hind legs, pushing back the dirt from the mouth of its hole with its long hairy hind legs. As soon as its hole was a few inches deep, perhaps four or five, it flew off to the grassy bank close by and immediately returned with a green

FIG. 59.



Sphex Wasp.

grasshopper which it had evidently stung and paralyzed, as it did not kick and struggle. It disappeared for a few minutes in its hole, long enough apparently to lay an egg in the body of the grasshopper, which was destined only to awake from its death-like lethargy to find itself the prey of the young Sphex.

That the sting of the wasp is so wonderfully guided as to pierce one of the nervous centres (ganglia) of the grasshopper, so that the insect is paralyzed, is proved by the observations of a French naturalist, Fabre, who has given us

a charmingly written account of his experiences with a wasp called Cerceris, which had been known to sting, and consequently paralyze, its prey, consisting of the larva or grub of a certain weevil. M. Fabre waylaid a Cerceris returning with her booty, and substituted a fresh, uninjured weevil grub for the one paralyzed. "This experiment succeeded to admiration. As soon as the Cerceris perceived her prey to have slipped from her grasp, she struck the earth with her feet, and turned impatiently hither and thither: then, suddenly perceiving the living curculio, placed close to her by M. Fabre, pounced upon it, and proceeded to carry it off. Instantly, however, discovering it to be still uninjured, she placed herself face to face with it, seized its rostrum between her powerful mandibles, and pressed her fore legs heavily upon its back, as if to cause the opening of some ventral articulation. Quickly then she slid her abdomen beneath the curculio, and struck her venomous dart sharply twice or thrice into the joint of the prothorax, between the first and second pair of legs. In one second, without a convulsive movement, without those twitches of the limbs which generally accompany the death agony of any animal, the victim dropped motionless, struck as if by lightning. The Cerceris then, turning the apparently lifeless insect on its back, embraced it as before described, and bore it away in triumph. Three times did M. Fabre repeat this interesting experiment, each time with precisely similar results. It must be clearly understood that on each occasion he restored to the Cerceris her original captive, and took possession of that which he had himself provided, in order to examine it at his leisure. Greatly did he marvel at the dexterity with which the fatal stroke had been dealt. Not the slightest trace of a wound was to be found; not the least drop of vital liquid spilt. The puncture made by the sting of the Cerceris is indeed so microscopic that chemistry can furnish no poison sufficiently powerful to produce with so

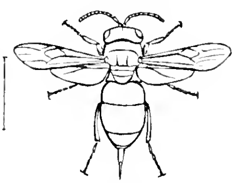
small a quantity so startling an effect; and it is, in fact, not so much to the venom of the dart as to the physiological importance of the exact point at which it enters, that we must ascribe the cessation, so complete, so instantaneous, of all active life.

"In most insects there are three ganglia, which furnish the nerves of the wings and legs, and on which the power of movement principally depends. The first, that of the prothorax, is distinct from the others in all Coleoptera; but the last two, those of the meso- and meta-thorax, though generally separate, are in some species united. Now it is a well-known fact that, in most cases, the more closely the nervous system is united, *centralized* as it were, the more perfect are the animal functions, and also, of course, the more easily vulnerable. Therefore the Cerceris, whose instinct teaches her at one stroke to annihilate these functions, chooses her victims precisely from the species in which this centralization is most complete.

"In order completely to establish his opinion, it remained for M. Fabre to prove that he could by similar means produce a similar result. And this he found himself able to perform with perfect ease, by puncturing the insect with a needle dipped in ammonia at the prothoracic joint, behind the first pair of legs. Any corrosive liquid applied to the thoracic medullary centre would have the same effect." His experiments were made upon the grubs of various beetles. "In the case of Scarabæi, Buprestes and Curculionidæ, the effect of his experiments was instantaneous; all motion ceased suddenly, without a single convulsion, at the instant the fatal drop touched the medullary centre. Not the dart of the Cerceris herself could have a more prompt or lasting effect. Notwithstanding their complete immobility M. Fabre's victims remained alive for three weeks or a month, preserving the flexibility of all their joints, and the normal freshness of their viscera."

My own observations on another wasp (*Odynerus albophaleratus*), which makes its round cells of clay, placing them for safety in the l ose nest of the American Tent Caterpillar, have shown me that Fabre's account must be correct. On opening these cells, they were found to be filled with minute caterpillars, which were in various stages of growth between the fully formed caterpillar and the chrysalis. They were alive, but benumbed, and in some cases with life enough to finish their transformations into the chrysalis state. Here they were waiting patiently each for his turn to be devoured by the young wasp. What a marvellous instinct on the part of the wasp, and how much more wonderful when we remember that this is a habit of but certain groups of wasps, and that it must have been acquired by them from some ancestor which had to find out for itself the secret of stinging its victim so as to simply paralyze and not kill outright the luckless subject of the experiment. Again, was the discovery made by accident, or did our ancestral wasp go about it like a philosopher, and after conducting a series of experiments, guided by the "scientific use of the imagination" alight finally upon just the weak spot in its victim's harness in which to insert its sting? This thought may be considered as twaddle by some, but in all seriousness we would say that nature must have had that insect in training. Any one who has observed a wasp building its nest, or a Chrysis wasp (Fig. 60) exploring the nail holes in a post with its inquisitive sting, combining the terrible qualities of a poisoned dagger with the delicate touch of a finger, and then imagines the series of deductions following each trial of the sting, the momentous result attending the exploitation to the future weal of the Chrysis family, and the ultimate good to the species — how can he say that there we

FIG. 60.

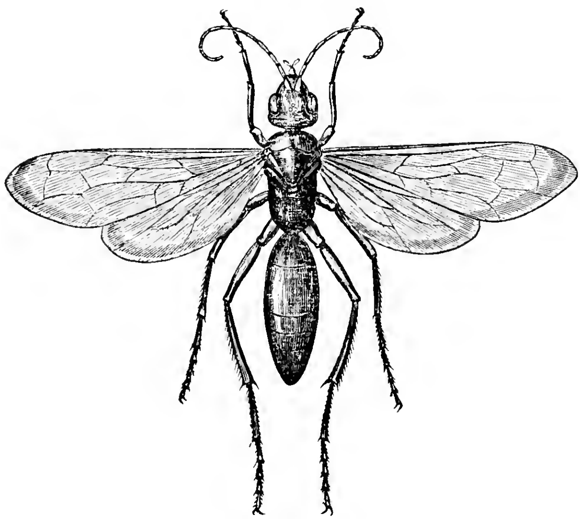


Chrysis.

have not a reasoning being under the tuition of nature's laws?

In like manner the Tarantula Killer (*Pompilus formosus*, Fig. 61), according to an exceedingly interesting account published by Dr. Lincecum in the "American Naturalist" (May, 1867), attacks that immense spider, the *Mygale Hentzii* (Fig. 61), paralyzes it with its formidable sting, and, inserting an egg in its body, places it in its nest, dug to the

FIG. 61.



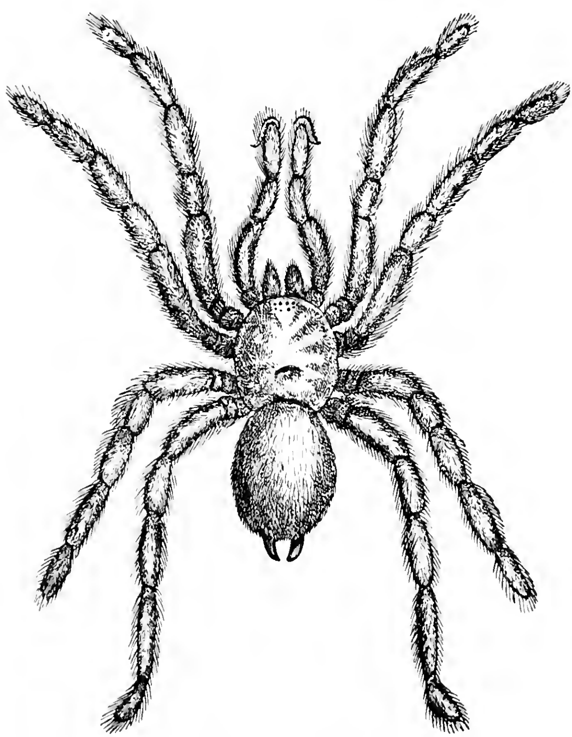
Tarantula Killer.

depth of five inches. There are hundreds of other species of wasps thus solely dependent on the adroit use of their stings for the means of providing for their offspring.

The poison of the spider, which is seldom fatal to man, is lodged in a little gland or sac situated in the head-thorax, and which opens into the jaws, which are hollow, perforated at the end so as to allow the poison to flow into the wound made by the mandible. But very few spiders are poisonous

to man. Hentz, our best American authority, after twenty years of study declared that spiders were not poisonous to man. Blackwall, the English authority, says that none in England are poisonous, as he allowed them to bite him on

FIG. 62.



Trap door Spider, Mygale.

different parts of his person without any harm resulting. Occasionally we see deaths reported from the bite of spiders. A late number of "Nature" contains a notice of the Katipo, or venomous spider of New Zealand. Its bite is "occa-

sionally fatal and certainly very painful and distressing." This spider belongs to the genus Latrodectus, and Walckenaër, says the same journal, writing of the *Latrodectus malmignatus*, an allied species common in Sardinia and Corsica and parts of Italy, remarks :—"This spider is certainly poisonous; its bite, they say, causes in man pain, lethargy and sometimes fever." A species of the same genus which lives in Georgia is said by Hentz (and not Abbot as "Nature" says) to have an "undoubtedly venomous" bite.

As regards the bite and habits of the scorpion, the testimony of Anderssen, the African traveller, may be cited as the common experience of inhabitants in the tropics. He says "The instant the scorpion feels himself in contact with any part of the body of a man or beast, he lifts his tail, and, with his horny sting, inflicts a wound which, though rarely fatal, is still of a painful nature. Like the snake, the scorpion is fond of warmth; and it is not uncommon, on awakening in the morning, to find one or two of these horrid creatures snugly ensconced in the folds of the blanket, or under the pillow. On one occasion I killed a scorpion, measuring nearly seven and a half inches in length, that had thus unceremoniously introduced itself into my bed."

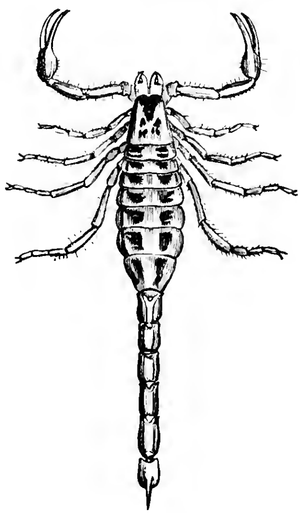
The poison gland of the scorpion, as everybody knows, is lodged in the tail. The scorpion is a timorous creature and only uses its sting when alarmed.

Dr. Lincecum has published in the "American Naturalist" an interesting account of the scorpion of Texas, a figure of which we reproduce (Fig. 63). He says that it dwells under old logs, rocks, in old stumps, under the bark of dead trees, under old fences, between the shingles on house-tops and particularly about the jambs and hearths of fire-places. "In temper they are hasty and will employ their weapons on slight occasions. The pain caused by their venom, when injected into one's flesh, is very quickly felt and quite severe, giving the idea of a burning-hot fluid thrown into the system. It

does not last long, nor does it swell much, and is not so painful, nor does it produce so much inconvenience as the sting of the honey bee. In countries where they abound, people do not regard them with much terror. Chickens are very fond of them and voraciously devour every one they can find." The scorpion brings forth its young alive.

The centipede is an annoying and even dangerous insect; the poison glands are lodged in the head, opening into the

FIG. 63.



American Scorpion.

channelled jaws as in the spiders. The bite of the larger species is most formidable.

Few are aware how painful and annoying is the irritation set up by the hairs of certain caterpillars. The hairs of many kinds are finely barbed; such are those of the Ctenucha figured in our frontispiece. The caterpillar feeds on grass, and I extract from my notes an account of the mode in which it constructs its cocoon, tearing its slender barbed

hairs from its body and dextrously weaving them into a firm texture without the aid of silken threads, the hairs being held firmly in place by the barbs.

"June 13th, the Ctenucha larva began to construct its cocoon. Early in the morning it described an ellipse, upon the side of the glass vessel, of hairs plucked from just behind the head. From this elliptical line as a base, it had by eight o'clock built up rather unequally the wall of its cocoon, in some places a third of the distance up, by simply piling upon each other the spinulated hairs, which adhered firmly together. At four o'clock in the afternoon, the arch was completed and the larva walled in by a light thin partition. Soon afterwards the thin floor was made. No silk is spun throughout the whole operation. I afterwards carefully examined portions of the cocoon under the microscope and could detect no threads of any kind."

From this it will appear that aside from their defensive nature, these barbed hairs come into play when the insect prepares to lay aside its caterpillar skin like an old garment, and go into retirement as a chrysalis. So also the hairs of the "woolly bear" caterpillar (*Arctia isabella*) and of the common Vanessa butterfly (*Vanessa Antiopa*) are poisonous to children.

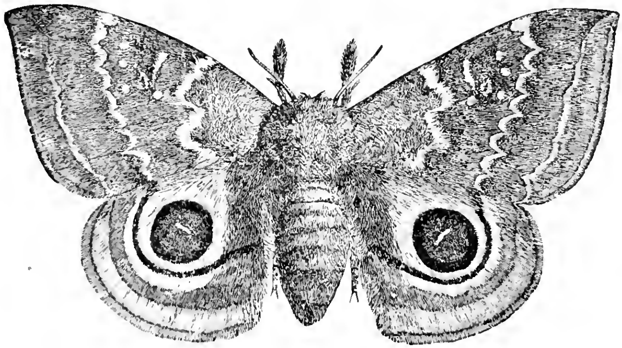
The caterpillar of another moth, the *Empretia stimulea*, is said by Dr. Clemens to be very annoying. "The spines with which the horns are supplied produce an exceedingly painful sensation when they come in contact with the back of the hand or any portion of the body in which the skin is thin."

The caterpillar of the Io moth (*Hypercheiria Io*, Fig. 64; 65 *a*, *b*, *c*, spines), which feeds commonly on corn in the southern states, though in New England it feeds on the maple, is covered with stinging hairs, which are often painful when detached.

The caterpillar of the Maia moth (*Hemileuca Maia*, Fig. 66 *a*, caterpillar) is armed with still more annoying spines.

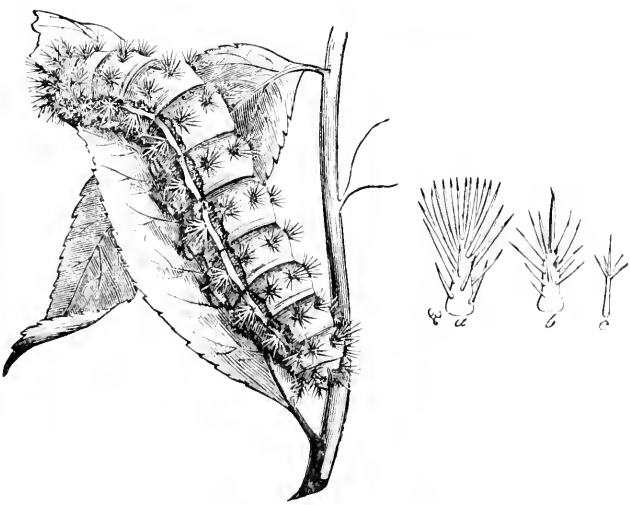
We are indebted to Mr. J. A. Lintner for an excellent account of certain experiments with this caterpillar, which

FIG. 64.



Io Moth.

FIG. 65.

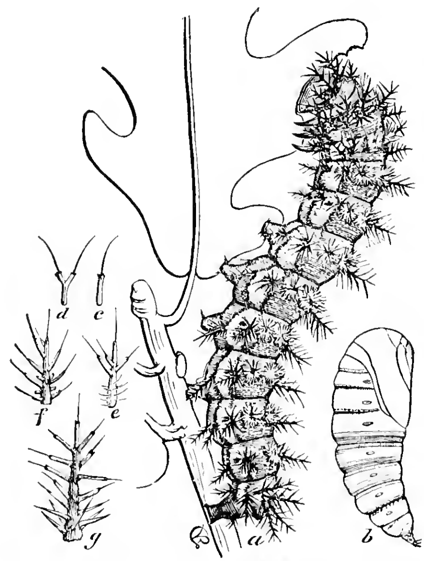


Caterpillar of Io Moth, after Riley.

we copy from his paper in the "Report of the New York State Cabinet for 1869." He remarks that "a larva was

dropped three or four times, from a height of about ten inches, upon the back of the first joint of the thumb. The sensation did not differ materially in kind from the sting of the nettle, but was more acute. In a few minutes the surface became reddened, and in a short time numerous slightly elevated whitish blotches made their appearance, accompanied with a burning and itching. The following day the thumb could not be bent without experiencing a sensible

FIG. 66.



Caterpillar and Pupa of Maia Moth, after Riley.

degree of pain, which was materially increased by an attempt to bring the joint to a right angle. This stiffness of the joint continued for four days. When the blotches subsided, small purplish spots of coagulated blood appeared in their place, which by degrees became more circumscribed, until after the lapse of a few days, when they presented an appearance similar to that of grains of gunpowder burned beneath

the skin. These gradually disappeared; those nearer the surface by a scaling of the skin above them; those deeper, removed by the slower process of absorption, were visible at least two weeks. When the larva was permitted to fall upon the thicker skin of the palm of the hand, a slight stinging sensation was experienced and minute purple dots were developed, continuing a shorter time than the above.

"The sting is doubtless the result, not of broken tips of the spines remaining in the flesh — for none such could be observed by careful scrutiny with a lens — but of a poison secreted by the larva*, and probably injected through a minute aperture in the tip of the spine. Whether its excretion is voluntary or involuntary was not determined, it not having occurred to institute the simple experiment by which that point could readily have been ascertained. A slight motion of the larva, apparently a contractile one, was frequently observed to accompany the sting; but this may have been either defensive, or simply the consequence of alarm at being rudely touched.

"Some tips of the spines clipped off and placed between slides under a high magnifying power, showed, under varying pressure, a motion of fluid within them; but no apical opening could be discovered for its escape.

"The ability to inflict a sting does not belong to all the spines of the larva, but only to those of the two subdorsal rows on segments three to ten, and the dorsal spine on segment eleven. These differ from those elsewhere on the body in their fascicular arrangement, their lesser length, the regular taper of the branches, and their tawny color, as appears in detail in the description given of the mature larva. With this interesting structural peculiarity in mind, the larva may be handled with impunity, as was repeatedly done with the fifty or more individuals composing the colony from which these notes were drawn, in the frequent transfers, which they

* That a poison is secreted seems to us improbable.—A. S. P.

required as they approached maturity, to fresh food and cleansed quarters. With proper care, the thumb and fingers could safely be passed along their sides and beneath them, slowly raising them from the leaf or stem to which they were attached; but if attempted too hastily the larva throws itself in a circle, projects its defensive armor, and inflicts a sting which effectually releases it from the grasp."

Now while nature has protected these caterpillars from their insect enemies, though certain ichneumon flies prey upon them, they seem, whether by reason of their spiny hairs or stiff bristles or other cause, to be distasteful to birds. We are not aware how different are the tastes of birds for different food; as with us so with birds—*de gustibus non disputandum*. We observe how different and arbitrary are the tastes of the dog or horse or cat; so wild animals, including birds, have their individual preferences and dislikes for certain kinds of food. Certain it is that there are many kinds of caterpillars which birds will not eat. The false caterpillar of the cherry sawfly (*Selandria cerasi*) is said by Professor Winchell to be never eaten by birds. The currant sawfly worm, now so destructive in our gardens, is not eaten by birds. In my "First Annual Report on the Injurious and Beneficial Insects of Massachusetts, 1871," occur the following remarks on this point. "As this is an important and practical subject, let us digress for a moment, to notice some facts brought out by Mr. J. J. Weir, of the London Entomological Society, on the insects that seem distasteful to birds. He finds, by caging up birds whose food is of a mixed character (purely insect-eating birds could not be kept alive in confinement), that all hairy caterpillars were uniformly uneaten; such caterpillars are the "yellow bears" (Arctia and Spilosoma), the salt-marsh caterpillars (*Leucarctia acræa*) and the caterpillar of the vaporer moth (Orgyia) and the spring larvæ of butterflies; with these may perhaps be classed the European currant saw-fly. He

was disposed to consider that the "flavor of all these caterpillars is nauseous, and not that the mechanical troublesomeness of the hairs prevents their being eaten. Larvæ which spin webs and are gregarious are eaten by birds, but not with avidity; they appear very much to dislike the web sticking to their beaks, and those completely concealed in the web are left unmolested. When certain branches covered with the web of *Hyponomeuta evonymella* (a little moth of the Tinea family) were introduced into the aviary, those larvæ only which ventured beyond the protection of the web were eaten."

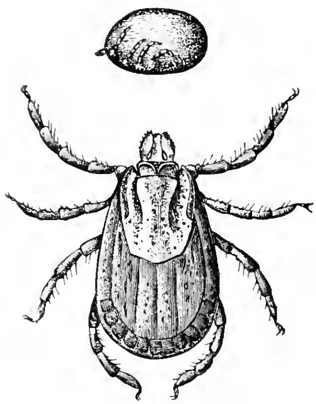
"Smooth-skinned, gayly-colored caterpillars (such as the currant Abraxas or span worm, Fig. 39), which never conceal themselves, but on the contrary appear to court observation" were not touched by the birds. He states, on the other hand, that "all caterpillars whose habits are nocturnal and are dull-colored, with fleshy bodies and smooth skins, are eaten with the greatest avidity. Every species of green caterpillar is also much relished. All Geometræ, whose larvæ resemble twigs, as they stand out from the plant on their anal prolegs, are invariably eaten." Mr. A. G. Butler of London has also found that frogs and spiders will not eat the same larvæ rejected by birds, the frogs having an especial aversion to the currant span worms (*Abraxas* and *Halia*)."

Before leaving the subject of poisonous insects we may refer to those which are indirectly so. Professor Leidy has, as we find in the "American Naturalist" (vol. vi, p. 694), entertained the opinion that flies are probably a means of communicating contagious disease to a greater degree than was generally suspected. "From what he observed in one of the large military hospitals, in which hospital gangrene had existed during the late rebellion, he thought flies should be carefully excluded from wounds. Recently he noticed some flies greedily sipping the diffluent matter of some fungi of the *Phallus impudicus*. He caught

several and found that on holding them by the wings they would exude two or three drops of liquid from the proboscis, which, examined by the microscope, were found to swarm with the spores of the fungus. The stomach was likewise filled with the same liquid, swarming with spores."

Among other insects which frequently annoy travellers in the southern states and in the tropics are the ticks (Fig. 67). It is the habit of these beings to climb up bushes and stalks of grass and attach themselves by means of their outstretched legs to whatever animal passes by, whether a

FIG. 67.



Cattle Tick, enlarged.

beast or lizard or snake, as they occur on all creeping animals. Having attached themselves by their jaws to the skin, they burrow beneath it, causing a painful tumor. It is difficult to pull them out as they are anchored in the flesh by their many-barbed tongue.

We turn again to Anderssen's narrative for an account of the plague this tick may be to the wanderer in Africa.

"Besides myriads of fleas, our encampment swarmed with a species of bush-tick, whose bite was so severe and irritating, as almost to drive us mad. To escape, if possible, the

horrible persecutions of these blood-thirsty creatures, I took refuge one night in the cart, and was congratulating myself on having at last secured a place free from their attacks. But I was mistaken; I had not been long asleep before I was awakened by a disagreeable irritation over my whole body, which shortly became intolerable: and notwithstanding the night air was very sharp and the dew heavy, I cast off all my clothes and rolled on the icy-cold sand, till the blood flowed freely from every pore. Strange as it may appear, I found this expedient serviceable.

"On another occasion, a bush-tick, but of a still more poisonous species, attached itself to one of my feet; and, though a stinging sensation was produced, I never thought of examining the part, till one day, when enjoying the unusual luxury of a cold bath, I accidentally discovered the intruder deeply buried in the flesh, and it was only with very great pain that I succeeded in extracting it, or rather its body, for the head remained in the wound. The poisonous effect of its bite was so acrimonious as to cause partial lameness for the three following months. The bush-tick does not confine its attacks to men only, for it attaches itself with even greater pertinacity to the inferior animals. Many a poor dog have I seen killed by its relentless persecutions; and even the sturdy ox has been known to succumb under the poisonous influence of these insects." Sometimes also while one bivouacs on the ground, these ticks will enter the ear and become exceedingly troublesome. These and other insect intruders can be made to leave their retreats by pouring a drop of oil into the ear.

Fig. 67 gives an excellent idea of the common cattle tick of the south when gorged with blood. The lower figure represents the tick when younger and after fasting. (The upper figure is of the natural size, the lower several times enlarged.) Fig. 68, adult, and six-legged young. Fig. 69 shows the mouth parts much enlarged, with the spiny tongue.

Ticks are gigantic mites. The smaller mites are in some rare cases found even in the veins and arteries of various birds. Among the mites belong the itch mite, and an allied

FIG. 68.

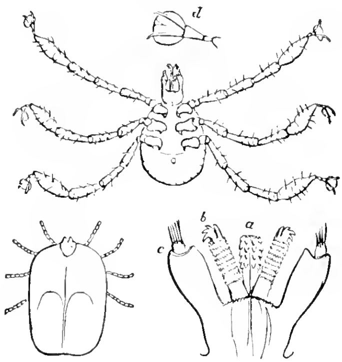
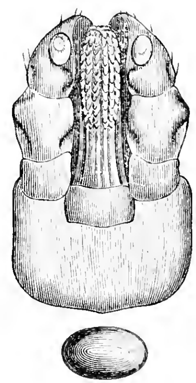


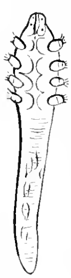
FIG. 69.



Tick, and six-legged young.

form, the *Acaropsis Mericourti*, was found in the pimples on the skin of a French officer who had been in Havana, Cuba, and was afflicted with an exanthematous eruption. M. Tandon, who figures the mite, thinks that it is a kind peculiar to this exanthema. We have seen a similar, though probably different mite taken from the nose of a person in New Orleans. We might before leaving this subject draw attention to the accompanying figure of a long slender mite (Fig. 70, *Demodex folliculorum*) sometimes found in the follicles of the face.

FIG. 70.



Demodex.

But there is a brighter side to the picture. Insects are not all leagued together to destroy our comfort and rob our pockets. There is the honey bee, one of our domestic animals; if well treated, patient and kind, ceaselessly at work for our benefit. Her life is a constant lesson of thrift and industry. Thanks to Messrs.

Langstroth, Quimby, and Wagner, bee culture has become with us one of the fine arts in agriculture, and a few hives are necessary adjuncts to a well conducted farm. The production of honey and wax has enormously increased in this country, and it is to be hoped that out of the thousands who keep bees, one or two at least may arise who, like Huber, Siebold, Leuckart, Dzierzon and Berlepsch in the old world, may advance our knowledge of the economy of the bee and its modes of reproduction, so intricate and wonderful, and thus lay still broader and deeper the foundations of scientific bee culture. We need not here speak at length on a subject so familiar to many as the structure and habits of the honey bee, and of the various other kinds of bees which store up honey. One point, however, and an important one, has quite recently been cleared up by a German naturalist, Professor Claus. The production of wax is a most important part of bee culture, especially in Catholic countries, where so many candles are used in churches. It is well known that the secretion of wax is carried on during the time when the workers are engaged in building their combs. We are all familiar, at least through pictures, with the festoons of bees hanging from the top of their hives. During this time of repose the secretion of the little disks of wax goes on. How is the wax secreted? The best authorities have differed on this important point. On the one hand Milne-Edwards, the distinguished French naturalist, supposed that the wax-secreting apparatus consisted of special glands, while an equally eminent German, Von Siebold, thought that no such glands existed. A countryman of Von Siebold, however, Prof. Claus, has, from special investigations of his own, confirmed Milne-Edwards' suppositions. I quote from a translation of a part of Claus' article in the "Guide to the Study of Insects." "The wax-secreting apparatus consists of special dermal glands as Milne-Edwards supposed. Claus has shown (see Gegenbaur's Vergleichenden Anatomie) that

these minute glands are mostly unicellular, the external opening being through a fine chitinous tube on the outer surface of the integument. In the wax-producing insects, the glands are developed in great numbers over certain portions of the body. In the Aphides, whose bodies are covered with a powder consisting of fine waxy threads, these glands are collected in groups. Modifications of them appear in the Coccidæ. In the wax-producing Hymenoptera the apparatus is somewhat complicated. The bees secrete wax in thin, transparent, membranous plates on the under side of the abdominal segments. Polygonal areas are formed by the openings of an extraordinarily large number of fine pore canals, in which, surrounded by very numerous tracheal branches, the cylindrical gland cells are densely piled upon each other. These form the wax organs, over which a fatty layer spreads. In those bees which do not produce wax, the glands of the wax organs are slightly developed. Wax organs also occur in the humble bees." I find in the "Academy" for Feb. 13, 1873, that Dr. Von Schneider is of the opinion that wax (which he thinks is undoubtedly a secretion of the honey bee) "is formed chiefly at the expense of different kinds of sugar; but he considers that the production of wax from sugar cannot be maintained without simultaneous access to food containing nitrogen."

As regards the mode of production of honey, which we are much in the dark about, as we have heretofore only known that it is elaborated by some unknown chemical process from the food contained in the crop, and which is regurgitated into the honey cells, Von Siebold throws more light upon it by his able anatomical researches, aided by the chemist, Von Schneider. From the "Academy" we learn that "at the annual agricultural meeting, held in October, 1871, at Munich, a well known apiarian, Herr Mehring, exhibited a peculiar kind of honey that he named 'Kunst-Honig' (artificial honey), and which he had pro-

duced by feeding his bees exclusively with malt. This honey excited great interest, and the question was raised whether this substance was real honey, and whether, consequently, the bee was able to change malt-sugar in its stomach into honey. . . . . . Dr. Von Schneider arrived at the conclusion that the carbo-hydrates, sucrose and dextrose, contained in the malt are actually changed by the bee into honey sugar, and that Mehring's honey only differs from other honeys in the absence of the specific aroma which is imparted to them by the flowers from which the bees have been gathering. Now," adds the "Academy," in quoting the account from the "Bienen Zeitung" "after the fact had been established that honey and wax are not substances found as such by the bee, but are productions which have undergone chemical change through contact with the secretions of the insect, Prof. Von Siebold directed his attention to the investigation of the secreting organs, a branch of anatomy which indeed had not been entirely neglected, but which is now treated for the first time with regard to the special functions those organs appear to perform in the preparation of the products of the bee. Prof. Von Siebold distinguishes three entirely distinct and very complicated systems of salivary glands, two of which (a lower and upper) are situated in the head, and the third in the anterior part of the thorax, the latter having been erroneously regarded by Fischer as a lung. Each of them has separate excretory ducts, and is distinguished by a specifically different form and organization of the vesicles secreting the saliva. Each consists of a right and left glandular mass, with right and left excretory ducts. For the detailed account of their minute structure we must refer to the paper itself, and the plate accompanying it. It may however be mentioned that this extraordinary development of the salivary organs has been observed by Prof. Von Siebold in the workers only. The queen possesses only a rudiment of the lower cephalic system in the form of the

two orifices of the ducts, while the ducts themselves as well as the glands are absent, and the two other systems are much less developed than in the workers. In the drones not even the orifices of the lower cephalic system could be found."

We may now consider the other wax-producing insects whose products, at first found in such minute quantities, go to swell the wealth of nations, as in Great Britain alone about $1,000,000 worth of wax is used. While there is true vegetable wax formed on the berries of our Candlemas bush or Bayberry (Myrica) yet the pela wax of China is secreted by a certain kind of Coccus, or bark-louse. Westwood in his "Modern Classification of Insects" (vol. ii, p. 449) tells us that the *Coccus ceriferus* Fabr., described by Anderson in his letters from Madras (1781), and by Pearson in the "London Philosophical Transactions," 1794, is employed in the production of a white wax, the body of the female being enveloped in a thick and solid coat of it. We have with us certain kinds of bark lice which secrete a woolly mass which envelops their body. Such is the mealy bug found upon our house plants, and to which we shall again refer in subsequent pages.

We have glanced at some of the relations of insects to ourselves, and if some memories not altogether of an agreeable nature have been awakened, yet upon the whole it will be felt that these little beings serve some good purpose in the world, and minister in many ways to our personal comfort.

4. Insects of the Plant House.

HAVING glanced at some of the more common insects to be observed in our walks around the garden, we shall in this chapter confine ourselves to a more restricted field of observation, and be content simply with some glances around the plant house, a look at what may be found on the flowers in the parlor, or a survey of the insects of the petunias and geraniums in the cottage window. Every rose has its thorn, and, it may be added, its Aphides; the lily and azalea their Thrips, and the orange and oleander their scale insects. Few are the insects which afflict our household plants, but a great deal can be said of those few.

He who would know something of the marvels of biology, the origin of life and of specific forms, he who cares to trace anew the steps which Bonnet, Chamisso, Steenstrup and Owen trod in building up that wonderful theory of parthenogenesis, and learn how one insect may through a simple budding process cast off a thronging host of young, produced like the leaves which bud out from the tree, can in his room watch the Aphides of his roses or geraniums. He who would follow Herold, Kölliker, Zaddach, Claparède, Weismann and Kowalevsky in tracing the development of the insect from a primordial sphere of protoplasm to the adult, can employ the leisure of his winter evenings in such studies, observing each change through his microscope, and adding his mite to one of the grandest of biological studies, the growth and development of animals. Again, he who envies the delicate touch and deft fingers in unravelling the intricacies of insect anatomy, and emulates the master pieces of Straus-Durckheim or Newport, can try his patience and steadiness of hand in dissecting the insects of the conserva-

tory. Finally, he who would content himself with a thorough study of the insect crust, and trace the laws of growth of the insect frame, the principle by which the body walls are built up, one part at the expense of another, and would for himself rediscover Savigny's law of the identity of the jaws and antennæ with the legs, and acquaint himself with Audouin's grand generalizations regarding the composition of the thorax, and thus study the morphology of insects—in short, he who would study Nature, pondering as he walks, interrogating her at each step, training himself in the philosophy of science, striving after a combination of the insight of the poet with the inductive spirit of the natural philosopher, and thus avail himself of one of the shortest paths (if a short one he must take) to self culture, would do well to devote the leisure of his winter to the despised and neglected bugs on the plants in the window. If, reader, you are incredulous and think this mere rhapsody, try it. In the summer we are, mayhap, too much diverted by the attractions which draw us from one side to another and distract our thoughts. In the winter one is forced to be more of a specialist, and no one but a specialist need hope to obtain a far-reaching knowledge of natural phenomena. The great need of this country is educated specialists. We boast that everybody knows a little of everything. Let every one endeavor to learn a good deal of something.

So, good reader, provide yourself with a microscope, a Zentmeyer's student's stand we like best, with an inch and a half, a one-half and a one-fifth inch objective, such as Mr. Tolles makes, a Tolles triplet and stand for holding it, forceps, delicate scissors and needles mounted in handles, good strong eyes, a large stock of patience and fingers that are not all thumbs. Armed with these let us plunge into the wilderness of biology and follow the pioneers who have mapped out the path for us. Let us place an Aphis in the field of the microscope under the lowest powers. Remove

her tenderly from the rose or geranium. Confine her body within the animalcule box, and begin with the aid of the camera lucida to draw the creature. We learn to observe much more rapidly and accurately by drawing the object, while our thoughts are more aroused by the deliberate use of the pencil.

Observe the long slender feelers, or antennæ, those delicate tactile organs which act at once as feelers, as ears, and sometimes, as in the case of the carrion beetles, as noses, since it is by means of the sense organs lodged in the broad club-shaped feelers of these insects that they are enabled to scent their way to the carrion in which they lay their eggs. That they are delicate organs of touch any one can convince himself who observes the aphis or other insects while walking. Scarcely a step is taken until the air and ground or twig on which it treads has been thoroughly explored by these divining rods, which never fail in imparting knowledge on which their owner may be said to stake its life. No one, however slight his knowledge of the habits of insects, will deny that the antennæ are rightly called feelers. That the delicate sense of touch with which the antennæ are endowed sometimes serves insects, in the absence of all the other senses, is shown in the case of the cave insects, in some of which the eyes are entirely wanting. It is not unfrequently the case that the antennæ of cave insects are much longer and more delicate than those of their fellows which live an out-of-door life. Here the loss of sight has been made up to the insect by the increased sensibility of the feelers. Writers on the habits of cave insects (I refer particularly to the papers of the Danish naturalist, Schiödte) describe the extreme caution with which they explore the ground over which they are about to walk, feeling and groping in the dark for their prey, or watching the movements of their adversaries in this game of blind man's buff among the columns and stalactites of their grotto.

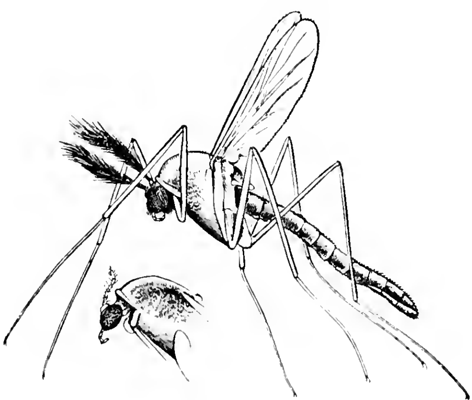
That the antennæ besides being feelers are also ears has been proved by Prof. A. M. Mayer. At a late meeting of the National Academy of Sciences, held in New York, he made a series of exceedingly ingenious experiments, which confirm the theorem of Fourier as applied by him in his propositions relating to the nature of a simple sound, and to the analysis by the ear of a composite sound into its elementary pendulum-vibrations; and which elucidate the hypothesis of audition of Helmholtz. Placing a male mosquito under the microscope, and sounding various notes of tuning forks in the range of a sound given by the female mosquito, the various fibres of the antennæ of the male mosquito vibrated sympathetically to these sounds. The longest fibres vibrated sympathetically to the grave notes, and the short fibres vibrated sympathetically to the higher notes. The fact that the nocturnal insects have highly organized antennæ, while the diurnal ones have not; and also the fact that the anatomy of these parts of insects shows a highly developed nervous organization, lead to the highly probable inference that Prof. Mayer has here given facts which form the first sure basis of reasoning in reference to the nature of the auditory apparatus of insects.

"These experiments were also extended in a direction which added new facts to the physiology of the senses. If a sonorous impulse strike a fibre so that the direction of the impulse is in the direction of the fibre, then the fibre remains stationary. But if the direction of the sound is at right angles to the fibre, the fibre vibrates with its maximum intensity. Thus, when a sound strikes the fibrils of an insect, those on one antenna are vibrated more powerfully than the fibrils on the other, and the insect naturally turns in the direction of that antenna which is most strongly shaken. The fibrils on the other antenna are now shaken with more and more intensity, until, having turned his body so that both antennæ vibrate with equal intensity, he has placed the axis

of his body in the direction of the sound. Experiments under the microscope show that the mosquito can thus detect to within five degrees the position of the sonorous centre. To render assurance doubly sure, Prof. Mayer, having found two fibrils of the antennæ of a mosquito which vibrated powerfully to two different notes, measured these fibrils very accurately under the microscope. He then constructed some fibrils out of pine wood, which, though two or three feet long and of the thickness of small picture-cord, had exactly the same proportion of length to thickness as the fibrils of the antennæ of the mosquito. He found that these slender pine rods or fibrils had the same ratio of vibration to each other as the fibrils of the mosquito."

Here a question arises. The song of the mosquito is undoubtedly a sexual call. Does the male detect the presence

FIG. 71.



Ocean Gnat.

of its female charmer by the different tones of her voice? Certainly the ears of the male with its feathered antennæ are far more acute than those of the opposite sex, the antennæ in her case mostly wanting those long vibratile hairs that give to him his acuteness of hearing. In this case

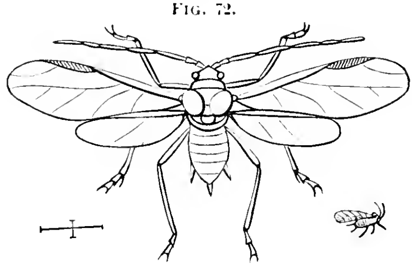
certainly the longest ears give the greater wisdom, however it may be among certain higher animals with a less number of feet than our mosquito boasts. The bushy antennæ of the feathered gnats (Chironomus) are perhaps still more acute organs of hearing than those of the mosquito, and here the great difference between the antennæ in the sexes may be seen by a glance at the accompanying figure (71) of the common ocean gnat of our harbors, the lower figure representing the antennæ of the female with their few short scattered hairs, while those of the male are very bushy.

The feelers of many moths are delicately feathered, those of the males being invariably with longer branches than in the other sex. They are particularly well developed in the males of the silk-worm moths, as for example in the large handsome Luna moth (see Pl. 2, representing, however, the female). The females of this group particularly are quite stationary, while the more active, restless males may be seen sailing majestically through the air in the twilight. If a female of this family be confined in a room or in a box out of doors, numbers of suitors for her hand and heart will come from far and wide. Collectors of insects take advantage of this trait, which they call "assembling." It is stated in an English work that an entomologist while walking out with a female Emperor moth in a box in his pocket was attended by twenty or thirty males fluttering anxiously about his person. They have also been known to seek their partners, held captive in the city of Manchester, from a distance of ten miles out of town. Now what is the faculty by which these sparks, with their antennæ gayly feathered and plumed, and wings, if not hearts, fluttering wildly, seek the presence of those undemonstrative if not stolid damsels? It is not by the sense of sight, because it is in the darkness of the night, and the darker and more foggy the night the better. Moreover, moths cannot see through the walls of houses nor into the collecting box in the pocket of the insect hunter.

It is not by the sense of hearing as in the mosquito, for these lepidopterous damsels have not the gift of song. They are silent as the Sphinx. It is not by the sense of touch, as they wing their way from places miles distant. Unless it is by the sense of smell, a modification it is true of the sense of touch, we are unable to account for this trait of assembling. That burying beetles perceive carrion at great distances through the sense of smell is not a matter of doubt, and it is not unreasonable to suppose that undulations of odoriferous particles, moving like waves of sound and light, strike the delicate branches and hairs of the male antennæ, causing them to vibrate in unison, and thus powerfully excite the amatory nature of these ardent suitors.

So much for the feelers of insects in general and those of our Aphis (Fig. 72) in particular. Now as we are drawing

FIG. 72.



Aphis.

the legs we may notice that there are six of them attached to the sides of the middle region of the body, the "thorax." The number is invariably six in all winged insects. The thorax consists of three segments or rings, and to the side of each ring a pair of legs is attached. Now the legs are tube-like, jointed at intervals, ending in two short toe joints. In most insects there are five such joints in the toe, and ten joints in all. The last joint ends in a pair of long and slender claws.

The hind body, or "abdomen," is full and rounded, aldermanic in its proportions, and provided with two tubes, which

project out from near the end of the body. From these two tubes issues the so-called honey dew, the delight of the sweet toothed ant. When a brood of aphides are busily engaged in tapping the stems of some plant, and the honey dew is dropping upon the ground or leaves below, a procession of sable ants enliven the scene.

This sweet fluid is also designed to afford nourishment for the young as soon as hatched. Both Bonnet and the Belgian naturalist Morren observed that the young Aphides as soon as born sucked up the fluid with their beaks, and thrived upon that for a while, before attacking the juices of the plant itself.

It has been a matter of curiosity to us how this thin fluid is secreted. Morren * has demonstrated that these tubes are in reality modified respiratory organs, as Bonnet had supposed. They are simply tubular elongations of the skin with a hole at the end, into which the air enters, while the sweet fluid escapes from the same hole. On dissecting the little creature, a task requiring much time and patience, Morren found a net-work of air tubes (tracheæ) near the base of each tube. This tube, he says, is "only a prolonged stigma, and it becomes evident that it is the air of these tracheæ which forces out the fluid with which this appendage is often filled." At the base of the tube he also found a gland which secretes the sweet liquid. The latter passes into the tube or excretory canal at the same time as the air within presses out. The viscous liquid is thus thrown out during expiration. Morren tells us that he has "several times seen the young Aphides suck the end of these tubes while holding their beaks near it. This always happened whenever I was able to have the females bring forth their young in vials without any leaves to serve as food for either the young or its mother. Now a gland situated on the surface of the body, provided with an excretory canal, and secreting a sweet fluid intended to nourish the young is in fact

*Annales des Sciences Naturelles. Tome 6. Second series, 1836. Paris.

a mammary gland," and he then compares these insects in this respect to the mammals.

Now upon pressing the body of the Aphis, placed in a drop of water in the animalcule stage, we readily squeeze out the contents of the abdomen, including the ovaries. Instead of a numerous mass of eggs in various degrees of maturity, we are astonished to see a series of young Aphides, in various stages of development. The creature brings forth its young alive. Moreover, the parent, as Bonnet observed, is a virgin. No males are in existence. The first brood hatching out in the spring are all females. As soon as the leaves unfold the virgin rears its brood of young; these in turn produce their spinster offspring, and the number of broods is only limited by the approach of frost. Finally, after from eight to ten broods, males and females appear; the latter lay fertilized eggs, by which the species is represented during the winter. Such are the powers of multiplication of these Aphides that a spring-born virgin may become the happy mother of a quintillion daughters and granddaughters. At least such is the belief of M. Fougard as quoted by Prof. Morren in his well known paper "Sur le Puceron du Pêcher." A certain species which Fougard calls "Puceron lanigère" produces ten viviparous generations and one oviparous generation. Each generation produces from ninety to one hundred and fifteen individuals, the mean of which is one hundred. He thus obtains the following table of generations: —

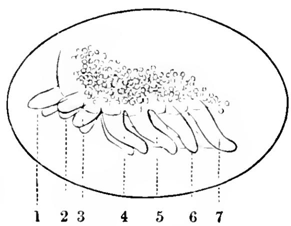
Generation.	Produce	
1st	1.	Aphis,
2d	100,	one hundred.
3d	10,000,	ten thousand.
4th	1,000,000,	one million.
5th	100,000,000,	hundred millions.
6th	10,000,000,000,	ten billions.
7th	1,000,000,000,000,	one trillion.
8th	100,000,000,000,000,	hundred trillions.
9th	10,000,000,000,000,000,	ten quadrillions.
10th	1,000,000,000,000,000,000,	one quintillion.

Regarding this estimate of what one Aphis can do to populate the world, Prof. Huxley makes the following statement: "I will assume that an Aphis weighs one-thousandth of a grain, which is under the mark; a quintillion will on this estimate weigh a quadrillion of grains. He is a very stout man who weighs two million grains; consequently the tenth brood alone, if all its members survive the perils to which they are exposed, contains more substance than five hundred million stout men, to say the least more than the whole population of China." That the individual with the potential ability to produce such a mass of young only succeeds in leaving perhaps two eggs to represent its species at the beginning of winter, all its offspring dying off, is a significant fact, illustrating forcibly the terrible struggle for existence going on in the animal world.

I scarcely know how to present in a popular way the mode of growth of the embryo Aphis. It has been well described by Huxley, and in a more exhaustive manner by the Russian naturalist Metznikoff. This study of the earliest phases in the life of an insect, or in fact any animal, leads us up to the very threshold of the mysterious portals of life. The problem given is, a sac full of protoplasm, a drop of jelly like the jelly in the cell of a plant, to our eyes the same, so far as our finite analysis at present extends, and yet potentially an animal, even representing the initial point of man himself. How is this result attained? This drop of oily jelly contains another sac filled with albumen, called the nucleus. Now when that mysterious act, the mingling of the contents of a sperm cell with the ovarian cell, or as in the virgin Aphis, the act of budding—the simplest generative process known—has occurred, let us with the practised eye of our Russian guide watch the behavior of the two elements, the general oily contents of the egg, or yolk, and the albuminous nucleus. The original protoplasmic mass has, prior to the union with a sperm cell, increased in size and

become filled with yolk cells or granules. After fertilization the nucleus subdivides into smaller cells. These seek the outer region of the egg. They multiply a thousand fold, become pressed together, lose their character as distinctive cells and form a pale band partly or wholly surrounding the yolk mass. This is the primitive band, the germ, which grows at the expense of the yolk cells. Finally feet and jaws and antennæ bud out from the band, until the form of an Aphis is rudely sketched out. Mark the fact, one of the most interesting in the morphology of animals, that at first the only difference between the antennæ and jaws and the legs are in their position. Identical in form, the antennæ and jaws differ from the limbs simply in the fact that they are situated in front of the legs. Now as each pair of appendages, whether legs or jaws or antennæ, indicate a segment or ring, we at once get a clew by which we can easily settle the question of the number of segments in the head of the winged insects. Here, following one another in orderly succession, are four pairs of protrusions like the fingers of a glove, beginning with the antennæ, the foremost, and ending with the labium, the pair next the legs. So we have four segments in the head. In after life the segments, clearly to be seen in the embryo, become so coalesced that it is impossible to define their limits. In most books the head is quite wrongly counted as one segment.

FIG. 73.



Embryo of Dragon Fly.*

An important point clearly demonstrated by Metznikoff is one bearing on the question of the origin of sex. It is maintained by some that well-fed caterpillars, for example, produce female butterflies, while starved ones produce males.

* 1, antennæ; 2, mandibles; 3, first pair of maxillæ; 4, second pair; 5-7, legs.

But it is generally and correctly thought that sex is determined at the time of conception. Now in the Aphis embryo, at a stage long before even the rudiments of feet appear, Metznikoff figures certain cells which are destined to form eggs, and soon after the germ has acquired limbs a mass of these eggs may be plainly seen. So the egg is to our eyes feminine almost as soon as it begins to grow.

It is interesting to watch the finishing strokes Nature puts to her master pieces. Shortly before hatching, the embryo, so far as regards the mouth-parts, resembles that of a fly or beetle or bee nearly as much as a bug; and it is to be remembered that the beak of the Aphis is really a very complex affair. It is composed of jaws (mandibles) and the front pair of maxillæ, which form two pairs of bristle-like organs ensheathed within the labium or under lip (second maxillæ). Metznikoff's figures show us how this wonderful transformation of parts takes place. How the mandibles and first maxillæ suffer an arrest of development, while the second pair of maxillæ are greatly enlarged and joined together to form the so-called labium or under lip, until finally the parts assume the beak-like form of the mature insect.

Thus from the simplest of beginnings the most complex results follow. "Give me a point on which to rest my lever," said Archimedes, "and I will lift the world." "Give me a drop of protoplasm," says the biologist, "and I will construct the world of animals and plants." Let us remember that all animals, as well as plants (except one-celled ones), result from the subdivision of a single primitive cell, and that, simple as this process is, yet mystery upon mystery accompanies each process. What is the power that urges on the self division of cells, that arranges them into forms so varied as the world presents? Is life a function of protoplasm? What is the difference between these sacs of protoplasm, that one becomes a plant, another a monad, another a fish, and another, to speak in the concrete, a Shakspeare

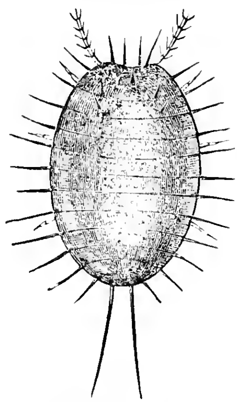
or a Humboldt? Simple as the process appears to our eyes, the determining cause is still an unfathomed mystery. The humble truth-seeking observer can only ponder and work on, hoping that the solution may be possible to his race. Certainly all is not known, when with some naturalists and philosophers we attempt to settle the question by saying that life is a function of protoplasm; though it is granted that life on this globe does not exist without it. For protoplasm is potentially a very variable substance, and life a problem quite beyond the science of our day to settle, whatever may be the flood of light thrown upon the question by modern science. The life force existing in protoplasm is powerless without an Infinite intelligence and will urging it on in its destined channels, just as muscular force is subject to the finite will that calls it forth. Though muscular force is a function of muscle, that does not account for a muscular act, nor does the nerve cell or fibre account for a nervous act; both are impelled by a will force not of themselves, as Matthew Arnold would say. So at the outset all life may have been the result of chemico-physical forces, producing from its elements, and acting upon the compound thus produced, which we call protoplasm. Still this act of "spontaneous" generation was none the less under the guidance of an all-pervading intelligence and will. Spontaneous generation is not self-creation.

So the study of our little Aphides ends in starting a series of questions that haunt us each step we take, some of them the largest that baffle the human reason. Certainly the mind of the naturalist need not grow rusty. Problems of matter and life and spirit assail him on every side, and the calmness, patience and breadth of conception their consideration involves are a fitting preparation for encountering the problems of his own existence.

Our studies over, now arises a practical question. How shall we exterminate these troublesome pests? In dealing with these insects in the hot house, where there are no insect

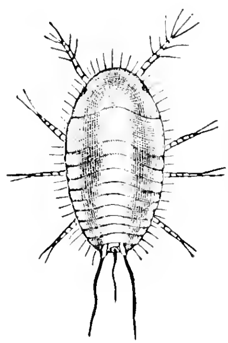
enemies, we are left solely to our own resources, so feeble compared with nature's. The best remedy against plant lice is to fumigate the plant house with tobacco. Shirley Hibbard says that the "best fumigator is one with a revolving fan, or a revolving cage containing the tobacco, by means of which the smoke is blown out in a rapid, dense, killing cloud; but an effectual instrument may be extemporized by knocking a hole in the side of a large flower pot, and then having put some hot cinders and damp tobacco in it, the nozzle of a bellows is placed against the hole, and ejection promoted by gentle puffing." Drenching the leaves with a syringe or

FIG. 74.



Mealy bug, female.

FIG. 75.



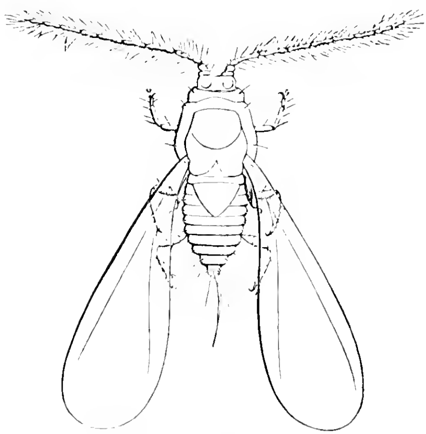
Scale insect (young).

hose, throwing hot water (150° F.) on them, is the best remedy against all plant house pests. After the drenching, sprinkle powdered tobacco over the leaves.

Scale Insects.—If we take an imaginary wingless Aphis, flatten the body, shorten and weaken the limbs, elongate the beak into threads, and endow it with a still more sluggish disposition, we shall have a scale insect in its simplest form, the "Mealy bug" of our conservatories (Fig. 74, enlarged). It may be seen on comparison with the immature or larval

form of the true scale insects (Fig. 75, enlarged) that the female Mealy bug is but little more advanced in organization than these larvæ, though greatly exceeding them in size. The male mealy bug (*Coccus adonidum* Linn.) is like the male scale insect (Fig. 76, enlarged), and still more nearly resembles that of the cochineal, which is two-winged, with two long caudal waxy threads. While the female Coccus undergoes no transformations, the male does, spinning a cocoon. Here we have a wonderful difference in form and

FIG. 76.



Pine Scale Insect, male.

habits between the sexes, the female attaining the adult state by simple increase in size of the larval form, while the male passes through a well marked metamorphosis. This shows conclusively that metamorphosis is an acquired mode of growth. The Coccus is a tenth of an inch long, covered with a white, cottony, mealy substance. The young are rather narrower than the old ones. The latter when about to lay its eggs, adheres by the long, slender beak to the surface of the leaf, and secretes from the abdomen a large cottony mass of fine particles of wax, which surrounds and partially

covers the end of the body, enveloping the pale orange oval eggs.

It is especially injurious to the camellia, hiding about the buds, to the azalea, oranges, lemons and similar plants. Washing the plants with strong soap suds is a good remedy. Prof. S. G. Maynard, in charge of the fine plant house of the Massachusetts Agricultural College, recommends washing

FIG. 77.

Woolly Scale Insect.

the plants with ninety-five per cent. alcohol, applying it with a small bristle brush. Few plants are injured by alcohol; they are the Pandanus, the paper Aralia and certain ferns.

A step higher in the family of scale insects (Coccidæ) and we come to the Lecanium bark-louse, of which the adjoining figure by Mr. Riley gives an admirable idea (Fig. 77 *a*, *Lecanium acericola*; *b*, *L. Maclura*, which lives on the Osage

Orange). The dark part is the insect, the pale portion the cottony or woolly down enveloping the eggs and young larvæ. The female is flat and scale-like, while the male is two-winged. All these scale insects are closely allied to the wax producing Coccus.

Professor Silliman informs us, in the "American Naturalist," that it may be "interesting to non-chemical readers to know that this insect wax is a definite compound somewhat resembling spermaceti in appearance, but not in composition, being a cerotic ether known as cerotate of ceryl, of the formula $C^{59} H^{108} O^{2}$. It is crystalline, and of a dazzling whiteness like spermaceti, but more brittle and of a more fibrous texture. It does not completely saponify by boiling in potash water, but is completely decomposed when melted with potash, yielding cerotate of potassium and hydrate of ceryl. It is consumed in China for candles and also as a medicine. It melts at about 118° F." Prof. Silliman quotes from a recent book by C. C. Cooper (Travels of a Pioneer of Commerce in Pig Tail and Petticoats, etc., London, 1871) the following interesting account of the cultivation of this wax insect. "On the third day we entered the white wax country, so named from its producing the famous white wax of Szchuan, which has been erroneously called vegetable wax. This district was less undulating than that of the tea gardens, and presented to the eye a view of extensive plains surrounded by low hills. The plains were all under wax and rice cultivation, the wax trees being planted round the embankments of the small paddy fields, which were at most thirty yards square. The country thus presented to the passing traveller the appearance of extensive groves of tree stumps, each as thick as a man's thigh and all uniformly cut down to a height of about eight feet, without a single branch. The cultivation of wax is a source of great wealth to the province of Szchuan, and ranks in importance second only to that of silk. Its production is not attended with much

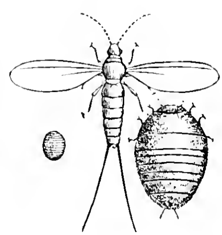
labor or risk to the cultivator. The eggs of the insect which produces the wax are annually imported from the districts of Hochin or Hoking and Why-li-tzou in Yunnan (where the culture of the eggs forms a special occupation) by merchants who deal in nothing else but pa-la-tan, 'white wax eggs.' The egg clusters which were described to me as about the size of a pea are transported carefully packed in baskets of the leaves of the pa-la-shu, 'white wax tree,' which resembles a privet-shrub, and arrive in Szchuan in March, where they are purchased at about twenty taels per basket. The trees by the middle of March have thrown out a number of long tender shoots and leaves, and then the clusters of eggs enclosed in balls of the young leaves are suspended to the shoots by strings. About the end of the month the larvæ make their appearance, feed on the branches and leaves, and soon attain the size of a small caterpillar or rather a wingless house fly apparently covered with white down, with a delicate plume-like appendage, curving from the tail over the back. So numerous are they that, as seen by me in Yunnan, the branches of the trees are whitened by them, and appear as if covered with feathery snow. The grub proceeds in July to take the chrysalis form, burying itself in a white wax secretion, just as a silkworm wraps itself in its cocoon of silk. All the branches of the trees are thus completely coated with wax an inch thick, and in the beginning of August are lopped off close to the trunk and cut into small lengths which are tied up in bundles and carried to the boiling houses, where they are transferred without further preparation to large caldrons of water, and boiled until every particle of the waxy substance rises to the surface. The wax is skimmed off and run into moulds in which shape it is exported to all parts of the empire.

It would seem that the wax growers find that it does not pay them to reserve any of the insects for their reproductive state, and hence the necessity of importing the eggs from

Yunnan. In the district of Hochin and Why-li-tzou, where the culture of the eggs is alone attended to, both frost and snow are experienced, so that it would not be difficult to rear the insect in Europe, and considering its prolific nature, the production of white wax might repay the trouble of acclimatizing this curious insect."

A near relation of the wax is the cochineal insect which affords us such an invaluable dye (carmine). This insect (Fig. 78, showing the wingless female, natural size and enlarged, and the two-winged male) is now abundant on the prickly pear in one corner of our Union (Key West) where we have found both sexes in great abundance. The "grain" is the female Coccus dried. So much has been written about this useful insect, of its mode of life and the methods of collecting and preparing it that we will not weary our readers with a repetition of it. Its value, however, in commerce is very great. In 1855, before red garments became fashionable, says Dr. Lankester in his "Uses of Animals," Great Britain imported 1400 tons of cochineal (it takes 70,000 of these insects to make a pound) which was valued at about £700,000, and since then their consumption has probably greatly increased. "Carmine," he adds, "is one of the most powerful of coloring matters; one grain of it, it is said, will dye a single silk fibre upwards of three thousand yards in length."

FIG. 78.



Cochineal Insect.

Other kinds of Coccus produce a carmine dye, and our own species, were the individuals sufficiently abundant, could be used for this purpose. Before cochineal was introduced into Europe, the bodies of another kind of Coccus, known as "grains of Kermes," were used in Europe, especially about the shores of the Mediterranean. Lankester says that "it is found extensively in Algeria, and the red Fez caps, which

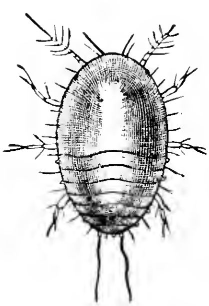
find their way into the European markets, are dyed with Kermes. Carmine is also made from it." Manna is said to be produced by the stings of the *Coccus manniparus* first described by Ehrenberg, who found it at Sinai growing on the tamarix. The lac insect, so valuable a commercial product, is a bark louse which lives in the East Indies on the *Ficus religiosa*. This insect, by its beak, punctures the bark especially of the branches. From this puncture exudes "a quantity of vegetable matter which eventually surrounds the lac insect and her eggs and larvæ, and produces on the branch an irregular brown mass, which encircles it and which when broken has a resinous aspect. This is gum lac." (Lankester). When found on the twigs it is called stick lac, but after it has been pounded, and the greater part of the coloring matter extracted by water, it is called seed lac; when melted down into cakes after it has been strained and formed into thin scales, lump lac and shell lac.

The most troublesome scale insect found on cultivated plants is the white scale insect or *Aspidiotus bromeliæ* (Fig. 79). The snow-white round scales crowd one another on the leaves of acacias, the Olea fragrans, Guidia simplex, etc. On examination with the microscope the dead and shrivelled body of the female may be seen in the centre. It is oval in form, with a ridge along the middle, and yellowish, contrasting with the snow-white thin edge of the scale, the surface of which is minutely granulated and white, as if frosted.

FIG. 79.

Aspidiotus bromeliæ.

FIG. 80.



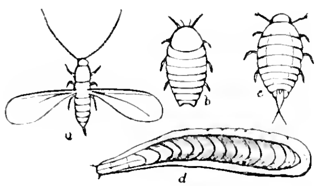
Young of A. bromeliæ.

The young (Fig. 80, enlarged) are thick and convex, with the hind edge simple. The segments (not all indicated in the cut) are quite indistinct. Around the edge of the posterior third of

the body is a series of minute tubercles, alternating with the fine hairs fringing the edge.

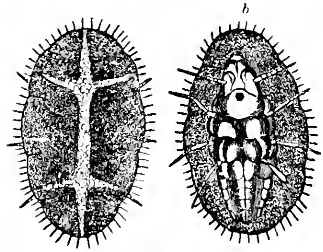
Another destructive scale insect is represented by figure 81 (*a*, male ; *b*, female ; *d*, scale ; *c*, female of another species

FIG. 81.



Orange Scale Insect.

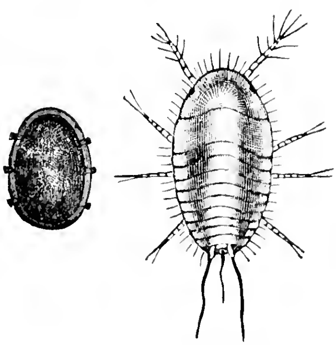
FIG. 82.



Fern Scale Insect.

also found on the orange). It is the orange bark louse, and infests both the orange and lemon. It is so abundant at times that all the branches of the plant have to be cut back to the trunk. It closely resembles the apple scale insect, and is called *Aspidiotus Gloverii*. It is possibly the *A. aurantii* or *citri* of southern Europe.

FIG. 83.



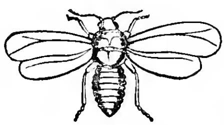
Lecanium platycerii and larva.

The fern bark louse, or scale insect (Fig. 82 ; *b*, underside ; enlarged), found frequently on ferns of the genus Pteris, seems to be identical with the Lecanium of the ferns, *L. filicum* of European authors. It is regularly oval elliptical. Along the middle of the body runs a prominent ridge, considerably thickened in the middle, with two transverse ridges. It is of a rosy tint, pale around the edge of the body, and with a darker patch in the angles between the median and transverse ridges ; beneath flesh-colored.

Another Lecanium found on the leaves of Platycerium alcicorne is *L. platycerii*. The scale is regularly oval, flattened, slightly convex above, with a slight ridge along the middle of the body. In dry specimens, especially the smaller ones, there are minute ridges radiating from the middle to the outer edge. The body of an adult female (Fig. 83, and larva, enlarged) is entirely flat beneath, finely granulated, and pale brown above. The young are thin and flat, scale-like, and of a light reddish brown color.

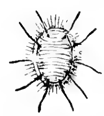
The Plant House Aleurodes.—Belonging to a group allied to the scale insects is a minute white-winged insect which may be found in all its stages on fuschias, the Salvia splendens, and out of doors in summer, the tomato, rising in clouds like snow flakes, when disturbed. These pretty, active beings (Fig. 84, enlarged) have pale, yellow bodies and pure white, unspotted, powdery wings, with dark red eyes; the beak is very long and dusky at tip, and reaches beyond the base of the thorax. In this genus both sexes are winged. The young of this species, the *Aleurodes vaporarium* of European authors, is broad, oval, thick, with a longitudinal ridge; the abdomen is wrinkled transversely, the head and thoracic segments being smooth. It is three-hundredths of an inch in length.

FIG. 84.



Aleurodes.

FIG. 85.



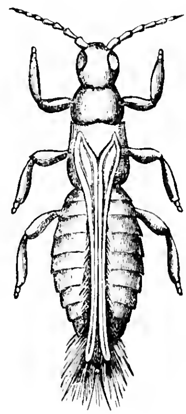
Pupa of Aleurodes.

The pupa (Fig. 85) is convex, rather thick, oval, elliptical, with a fringe of hair-like filaments around the edge of the body, from the top of which arise from six to nine long threads.

The Hot-house Thrips (Fig. 86, magnified).—This is one of the greatest pests in our hot-houses. It is the *Heliothrips hæmorrhoidalis* of Burmeister. In all its stages it may be found puncturing the leaves of liliaceous plants, azalias,

Pellea hastata, aspidium, pinks, etc., and by its attacks causing the surface of the leaf to turn red or white in blotches, or sometimes the whole leaf withers and whitens. The larva and pupa are white, long, with short antennæ. After several successive changes, it assumes the adult state, and the pupa may be found in different stages of growth, with the antennæ turned underneath the head, and the rudimentary wings folded to the sides of the body. The eyes are pink. The half-grown young are shorter and broader than those fully mature. The adult is black, with the extremity of the abdomen bright rust red. The antennæ and legs are white, the base and sixth joint of the former dusky, while the wings are almost hyaline. The body above is entirely covered with a net-work of elevated lines, forming pretty regular hexagons, equal in size on the head, where they are largest, to those of the eyes, and disposed in perfect rows on the abdomen. It is about one-twelfth of an inch in length.

FIG. 85.



Thrips.

The best remedy against them is repeated washings with soap-suds, cleaning each leaf by itself, or turning the hose upon the plants.

The Red Mite.— Usually called "red spider." This little mite (*Tetranychus telarius* Linn.) is a universal pest in hot houses, and in dry seasons abounds on the peas, etc., in gardens. Its eggs and young may be found on the rose and other plants of the conservatory all the year round. Its presence may be detected by the blotched and withered appearance of the leaves, and the small web. Frequent showerings will reduce its numbers. Sulphur dusted frequently over the leaves is an excellent remedy.

5. Edible Insects.

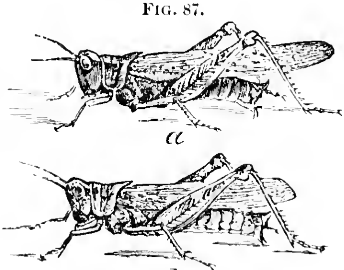
THE crustacea afford in the northern lobster, the spiny lobster of the tropics, and numerous kinds of shrimps and crabs, many choice bits for our larder. Whether, however, any of the insects, or their allies the spiders, or even the worms, will ever afford food to civilized man is a matter of grave doubt. While the bulk of our animal food is given us by the vertebrated animals, the ox, sheep, fowl and game being our main dependence, the mollusks afford us the delicious oyster which we shall never be able to give up, the less aristocratic clam, handed over to the Pilgrim Fathers by the sagamores and their followers, the delicious though rare scallop and the quahaug, while mussels, snails and whelks regale our transatlantic friends. Honey is universally sought, and that is an insect product, but the flesh of insects is, upon the whole, repugnant to our feelings. This is certainly unreasonable, for multitudes of the locust or grasshopper of the East are eaten by Arabs and the savages in other parts of Africa. We look with repugnance upon a roasted grasshopper, but an Arab is said to have expressed his abhorrence at our eating raw oysters. While in their sudden flights the grasshoppers cover the ground and eat up every green thing, the natives adopt the sensible course of devouring them in turn. The Bushman, who is no farmer, sings

> "Yea, even the wasting locust-swarm,
> Which mighty nations dread.
> To me nor terror brings nor harm;
> I make of them my bread."

He collects them, according to Andersson, by lighting large fires directly in the path of their swarms. As the insects pass over the flames, their wings are scorched and they fall

helplessly to the ground. They are also, he says, collected by cartloads when they have retired to rest. "The locusts, after being partially roasted, are eaten fresh, or they are dried in the hot ashes, and then stored away for future emergencies. The natives reduce them also to powder, or meal, by means of two stones or a wooden mortar, which powder, when mixed with water, produces a kind of soup or stirabout. I have tasted locusts prepared in various ways, but I cannot say that I have found them very palatable. But they must contain a vast deal of nourishment, since the poor people thrive wonderfully on them." He also states that "the Cape Colony has been particularly subject to this dreadful scourge, which is invariably followed by famine. The inroads of the locusts are periodical; according to Pringle, about once every fifteen years. In 1808, after having laid waste a considerable portion of the country, they disappeared and did not return until 1824. They then remained for several years but in 1830 took their departure."

FIG. 87.



Destructive Grasshoppers.

The locust is truly migratory, the undeveloped, partially winged young moving from one region to another. He quotes from Barrow, who says that "the larvæ at the same time were emigrating to the northward. The column of these imperfect insects passed the houses of two of our party, who assured me that it continued moving forward without any interruption, except by night, for more than a month."

Of very similar habits is our red-legged grasshopper (*Caloptenus femur-rubrum*, Fig. 87, *b*). It appears at intervals in immense swarms. In 1871 it was very destructive to grass in northern Maine, seriously damaging the hay crop.

It has also swarmed in Canada. Dr. Harris enumerates its visitations in New England in the last century when it devoured every green thing. The habits of this species are not well known, except that it appears in midsummer in the winged state. The wingless larvæ appear in June, and, as Harris recommends, hay crops should be mown early, before the insects fly in swarms. The last of summer they couple and lay their eggs in holes in the earth, where they are hatched in the spring.

As Harris suggests, this insect can only be kept under by concerted action on the part of farmers. "In the south of France the people make a business, at certain seasons of the year (probably in the autumn and late in the spring), of collecting locusts and their eggs, the latter being turned out of the ground in little masses, cemented and covered with a sort of gum in which they are enveloped by the insects." Various forms of drag-nets can be invented for collecting them in large numbers, and run, if necessary, through a field by horse-power. The inventive genius of our farmers will easily suggest methods of gathering these insects by the bushel, when they can be thrown into hot water, and fed to swine. An entomological friend has found by his own experience that roasted grasshoppers are excellent eating — "better than frogs." Only let some enterprising genius of the kitchen once set the example of offering to his customers roasted grasshoppers, rare-done, and fricasseed canker worms (for we have it on the word of an entomologist that caterpillars are pleasing to the palate of man), and these droves of entomological beeves will perchance supplant their vertebrate rivals at the shambles, and instead of cattle fairs, we shall have grasshopper festivals, and county caterpillar shows.

The *Caloptenus spretus* of Uhler (Fig. 87 *a*) appears in immense numbers in the country between the Mississippi and the Rocky Mountains, and extending from the Saskatch-

ewan river on the North to Texas. Mr. Scudder states that "a third, whether belonging to the same species or not is still uncertain, has invaded, at different times, nearly all the country lying within the boundaries of the United States between the Rocky Mountains and the Pacific Ocean."

Dr. Lincecum thus describes the ravages of *C. spretus* in Texas: "Last spring the young were hatched from the egg in the early days of March; by the middle of the month they had destroyed half the vegetation, although the insects were wingless and not larger than a house-fly. The first winged specimens were seen high in the air at about three in the afternoon; as a light northerly breeze sprang up, millions dropped to the earth, covering the ground in an hour, and destroying every green thing with avidity. During the night they were quiet, but at daybreak commenced to eat, and continued until ten in the morning, when they all flew southward. At about three o'clock in the afternoon of the same day another swarm arrived, ten times as numerous as the first; these again took flight the following day; and thus they continued, coming and going, day after day, devouring the foliage and depositing their eggs. At first they selected bare spots for this purpose, but finally the whole surface of the earth was so broken up by their borings that every inch of ground contained several patches of eggs. This visitation was spread over many hundreds of miles."

Of other insects eaten by man we may instance the humble bee whose body is often sacrificed to the love of boys for sweets, who since Shakspeare's time have searched for the "well bestratted bee's sweet bag;" while in Ceylon bees are eaten bodily as food. Some kinds of ants are eaten by the Indians of the Gulf coast of Mexico. Sumichrast says (see our "Guide to the Study of Insects," p. 187) that "the natives eat the females after having detached the thorax;" and Humboldt tells us that ants are eaten by the Indians of South America. Kirby speaks from his own

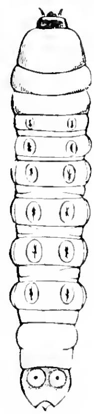
experience: he says "that ants have no unpleasant flavor; they are very agreeably acid, and the taste of the trunk and abdomen is different." He refers to the fact that "in some parts of Sweden ants are distilled along with rye to give a flavor to the inferior kinds of brandy." Certain galls are esteemed in Constantinople for their aromatic and acid taste, and Réaumur says that the galls of the ground ivy have been eaten in France, but he thinks it doubtful if they ever rank with good fruits (Kirby).

Réaumur has suggested that the numbers of injurious caterpillars might be judiciously lessened by our using them as food. Kirby and Spence in their admirable "Introduction to Entomology" give a list of the lepidopterous larvæ eaten by man.

"Amongst the delicacies of a Boshies-man's table, Sparrman reckons those caterpillars from which butterflies proceed. The Chinese, who waste nothing, after they have unwound the silk from the cocoons of the silkworm, send the chrysalis to table: they also eat the larva of a hawk-moth (Sphinx) some of which tribe, Dr. Darwin tells us, are, in his opinion, very delicious; and lastly, the natives of New Holland eat the caterpillars of a species of moth of a singular new genus, to which my friend, Alexander MacLeay, Esq., has assigned characters, and from the circumstance of its larva coming out only in the night to feed, has called it Nycterobius. A species of butterfly also (*Eublœa hamata* MacLeay), as we learn from Mr. Bennett, congregates on the insulated granitic rocks in a particular district which he visited in the months of November, December and January, in such countless myriads (with what object is unknown), that the native blacks, who call them Bugong, assemble from far and near to collect them, and, after removing the wings and down by stirring them on the ground previously heated by a large fire, and winnowing them, eat the bodies, or store them up for use by pounding and

smoking them. The bodies of these butterflies abound in an oil with the taste of nuts; and when first eaten produce violent vomitings, and other debilitating effects; but these go off after a few days and the natives then thrive and fatten exceedingly on this diet, for which they have to contend with a black crow, which is also attracted by the Bugongs in great numbers, and which they despatch with their clubs, and use as food" (Kirby).

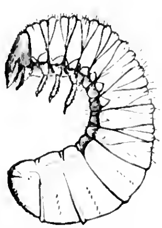
FIG. 88.



Prionus.

Among beetles the grubs of the gigantic palm weevil are roasted and eaten by natives in the tropics, and the larva of the large Prionus (much like the one here figured, Fig. 88) is "eaten at Surinam, in America, and in the West Indies, both by whites and blacks, who empty, wash and roast them, and find them delicious. Mr. Hall informs me, that in Jamaica this grub is called *Macauco*, and is in request at the principal tables. A similar insect is dressed at Mauritius under the name of *Moutac*, which the whites as well as negroes eat greedily," and Mr. Kirby, from whom I have quoted, thinks, with Dr. Darwin, that the grub of the common cockchafer might be added to our *entremets*. Who will set the example on this side of the Atlantic of eating the common white grub, or young of the May beetle (Fig. 89), so destructive to our strawberry beds?

FIG. 89.



May Beetle, grub.

The Cicada or harvest fly, to which Anacreon inscribes an ode, was eaten by the Greeks. Aristotle says that the pupæ are most delicious, and after they change to the winged state the males at first have the best flavor, while the females are better on account of the eggs. "Athenæus also and Aristophanes

mention their being eaten; and Ælian is extremely angry with the men of his age, that an animal sacred to the muses should be strung, sold and eagerly devoured." Kirby, from whom we quote, cites Peter Collinson as saying that the winged form of the seventeen year Cicada was in his time (1763) eaten by the Indians of North America. Lastly, the gravid, enormously distended female of the white ant is regarded as a delicious morsel by the Hottentots, and Smeathman "thought them delicate, nourishing and wholesome, being sweeter than the grub of the weevil of the palms."

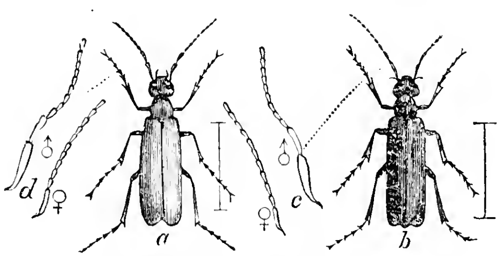
Roasted spiders are eaten by the natives of New Caledonia. Kirby says that "even individuals amongst the more polished natives of Europe are recorded as having a similar taste, so that if you could rise above vulgar prejudices, you would in all probability find them a most delicious morsel. If you require precedents, Réaumur tells us of a young lady who, when she walked in her grounds, never saw a spider that she did not take and crack upon the spot. Another female, the celebrated Anna Maria Scherman, used to eat them like nuts, which she affirmed they much resembled in taste, excusing her propensity by saying that she was born under the sign *Scorpio*. If you wish for the authority of the learned, Lalande, the celebrated French astronomer, was, as Latreille witnesses, equally fond of these delicacies." Even the centipedes are not neglected, as Humboldt records the fact that "he has seen the Indian children drag out of the earth centipedes eighteen inches long and more than half an inch broad, and devour them."

Even the eggs of certain insects are eaten. In Mexico the eggs of the Corixa, or water boatman, are often used as food, and in the same country the Indians prepare a liquor from the Cicindela (of which we figure a species) "by macerating it in water or spirit, which they apparently use as a stimulating beverage."

Druggists are indebted to insects for the Spanish fly, or blistering beetle (Cantharis) for an important article in the pharmacopœia. Our native species of Cantharis (Fig. 90, *a*, *Lytta cinerea*; *b*, *L. murina*), of which four are common all over the country, when dry and powdered, afford a good vesicant.

Were we living in the middle ages, or even as far back as the eighteenth century our *materia medica* would be swelled

FIG. 90.



Lytta, or blistering beetle.

by a long list of entomological nostrums, of which Kirby and Spence afford us an amusing list.

As we are indebted to the ant for lessons of prudence and thrift, so has this humble creature given one of the greatest boons to poor suffering humanity. To the ant we are indebted for the discovery of chloroform. How the discovery of this prince of anodynes came about Dr. Lankester tells us in his little work on the "Uses of Animals," p. 243.

"Some years ago, whilst editing the correspondence of John Ray, I was amused by the letters which passed between this great naturalist and Dr. Martin Lister of York, on the subject of the 'acid liquid of pismires.' It had been observed, that when ants were bruised their juices afforded an acid secretion, which substance was afterwards known as formic acid. The attention of modern chemists being thus called to formic acid, Dumas discovered that it contained a base, a compound radical, which he called formyle. This

base, with three atoms of oxygen, forms the formic acid. Now Dumas not only made this out, but he further discovered that the three atoms of oxygen might be replaced with three atoms of chlorine. He thus obtained terchloride of formyle. It so happened that, when ether had been employed as an anæsthetic, Dr. Simpson of Edinburgh was induced to look for some agent that might act even more beneficially than ether in this respect. He tried the terchloride of formyle, and found it to succeed; and this is the agent which under the name of chloroform, has been the means of alleviating a vast amount of human misery: and if occasionally it has destroyed life it has saved so much that mankind owes a deep debt of gratitude to those who have successfully introduced it into practice."

Such, then, are some of the relations in which insects stand to us. They feed us, clothe us, and lull us to sleep. The gorgeous hues and lines of grace of some fill our minds with visions of beauty; others, master pieces of ugliness, turn us to loathing. They are our companions by day, and, alas also by night. Finally, a thorough comprehension of their origin, structure and habits forms a part of that grand science —biology—which great intellects have through the centuries since the time of Aristotle, gradually and with much pains built up, and the end and aim of which is to seek the answer to the question—What is life? thus bringing the mind of the inquirer into closer relations with the Source of all Life.

6. Insects of the Pond and Stream.

A HISTORY of the insect inhabitants of a pond or stream would deal largely in the tragic. The biography of one aquatic insect from the time of its birth till its death, provided it completed the usual round of existence allotted to its species, would be a long and perhaps tedious record of escapes from its enemies, of its methods of avoiding or repelling their attacks, while on the other hand the pages of its biography would be largely occupied with a list of those it had killed and wounded, not from the mere love of carnage, but from the simple necessity of maintaining its own existence. If we reflect for a moment on the fact that out of about one hundred eggs laid by the dragon fly, perhaps only one pair survive the following summer, and that the remaining ninety-eight young have afforded food for other dragon flies and insects of other species; and then consider the amount of insect-food required to maintain the pair of dragon flies from the larval to the winged state, we shall be impressed with the fact that the majority of insects are born to serve as food for the few that survive.

Life among the lower animals, as in human affairs, is an intense struggle for existence, resulting in a triumph of the favored few over the masses. These few perpetuate the qualities which gave them success, and so we have a constant progress upwards of life from lower to higher forms, a survival of those best fitted by physical and intellectual qualities to maintain themselves in the world. There is genius, or preëminence in intellectual qualities, among insects. Ants choose generals and master workmen, whose lead they follow in their wars and public works. The queen bee is mistress of the kingdom over whic she rules.

It is not, however, simply a record of the triumph of brute force. Intelligence is everywhere guiding the operations of these unconscious, or possibly conscious, agents. The great interest in studying the habits of insects results from this fact of the immanence of mind in the animal world. Insects and animals generally are not mere "animated machines," with a "blind instinct" alone, operating under the rule of so-called inflexible physical laws; for these very "laws," as we call them, are in a state of unstable equilibrium. There was a time, before life originated, when the world was forming by the agency of cosmical laws; the biological laws became developed with the rise of animal and plant life. The laws of life, the processes of evolution, have changed and become more complex, as forms of life beginning with the Vibrios, Moners and Amœbas became differentiated into the grand groups of the animal and vegetable kingdom.

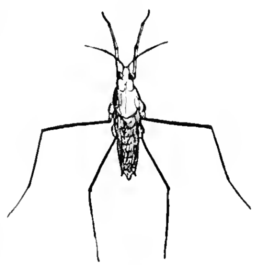
So the life of the individual, of the species, of the animal world collectively, is a long record of feats of strength, of mere animal courage opposed to cunning, skill and sagacity. The strong are saved by their size and strength, while on the other hand, as in the parasitic species, the very weakness of the weak is often their defence. In past ages insects were gigantic and low in intelligence, judging by their surviving relations; while the insects of the present day, as a rule, have smaller, more compact bodies, with their appendages more under the control of their intelligence. The most fitting have survived. The families and orders of the Neuroptera which are least numerous at the present day are those which have succumbed in this struggle for existence. The Hymenoptera and beetles comprise the most intelligent of insects, and they are, perhaps, the most numerous in species.

Had one been born in the Silurian period he would be excused for being a materialist of the Büchner school, but man of the Quaternary period, *i.e.*, of the present day, who

is able to reflect on this progress of life as the beneficent result of the struggle, mental and physical, for existence, of his own and other species; such an one, unless his faculties are quite unequally developed, cannot avoid a rational combination of materialism and spiritualism in his intellectual make-up. The very faculty he possesses of making this retrospect and studying his own mental operations, and of appreciating the Infinite Power working in material laws, separates him from the animals, and should teach him that he is not subject alone to physical, material laws.

So if, in looking back, the picture of the animal world evolving from a mere drop of protoplasm, of humanity struggling up from some ape-like form, seems sad, tragic, and gives a shock to the sensibilities of many, the final result is hopeful and inspiring. In connection with these profound problems of our own existence, the study of the habits, economy, structure and embryology of animals, their various contrivances for the maintenance of life, their evident enjoyment of life as long as it lasts, the gleams of intellect flashing out in their daily acts, all derive a fresh and startling interest.

FIG. 91.



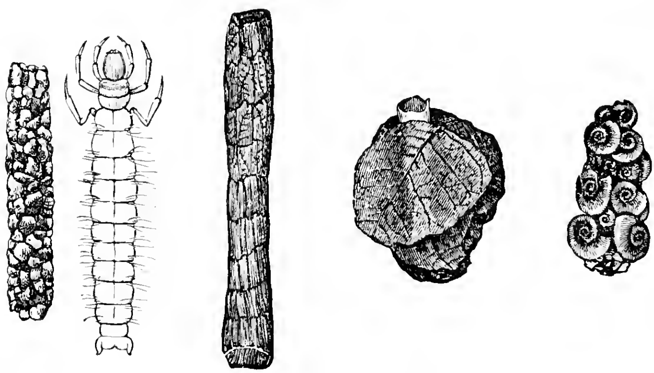
Gerris.

Among aquatic insects there are marvels of mechanical skill displayed in the construction of the bodies of the swimming and diving forms. The Gerris, or Wherryman (Fig. 91), of our streams, ages ago anticipated our racing boats and wherries. Our diving machines, whether known to their inventors or not, are modelled on the principle of the diving beetle and the diving spider. The mechanism of swimming in the Dytiscus engaged the attention of Straus-Durchheim, the famous French anatomist. Models of scissors, straight and curved, that would give new ideas to a Sheffield manu-

facturer, may be studied in the jaws of the young of these same diving beetles. The larval Corethra, a fly allied to the mosquito, is an excellent areometer, and other philosophical instruments have their counterparts in the special organs of insects adapting them for an aquatic life.

Cases of protective mimicry are afforded by the Caddis flies (Fig. 92), which move over the bottom, carrying about with them a movable *chevaux de frise* of sticks, behind which lurk a nimble pair of jaws; or they mimic innocent sticks, or build their cases of bits of moss and move about

FIG. 92.

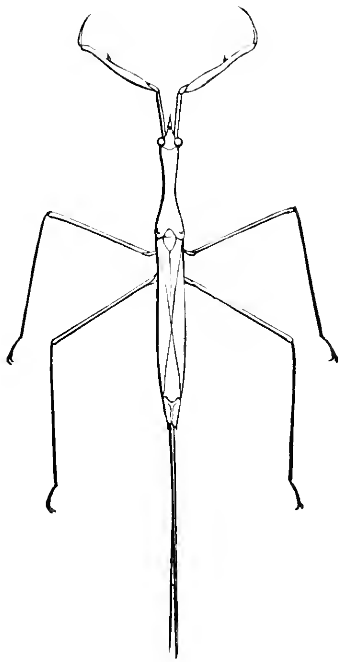


Different forms of Case Worms.

bearing, as it were, subaqueous Birnam forests; or when their tubes are built of sand imitate the irregularities of the bottom over which they creep, and thus living in ambush all the while, are protected in their turn by these disguises. As the Ranatra (Fig. 93) is noticed moving about slowly at the bottom of a pool, it would be easily mistaken for an ear of wheat moved accidentally. It is not so harmless as it looks, for its fore legs are held up in an attitude that will at least be deemed by its victims a striking one. When it strikes out those legs, the long claws close with a firm grasp

on the struggling worm, which is nailed to the leg by a spine opposite the end of the claw. Why its body is so long and linear in shape, we cannot imagine, unless for the purpose of concealment and protection, as its movements are labored and slow, as are those of Belostoma, its near ally, which, as

FIG. 93.



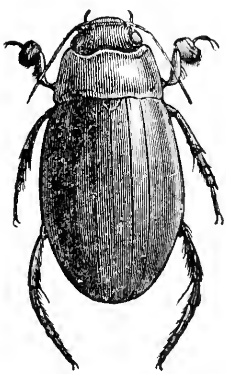
Ranatra.

has been remarked by others, closely resembles a dead leaf, as it lies at the bottom of the pond in wait for its prey.

So small a proportion of insects are aquatic that the question arises whether those that do live in our ponds and streams may not be the descendants of terrestrial forms. The ocean is the parent of all life ultimately, but only a

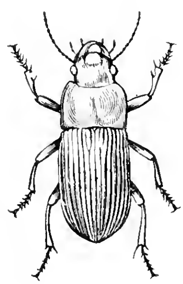
very few insects live in salt water, and it is easy to see that a maritime life is not a normal one to them. So in a less degree with the fresh water forms. The aquatic insects are representatives of scattered families, and though all are in various ways modified by their aquatic surroundings, yet so much do they differ in their modes of development and structure among themselves, that it is easy to see that they belong mainly to terrestrial types which have adopted an aquatic life after the type to which they had belonged had become fixedly terrestrial. For example, many beetles

FIG. 94.



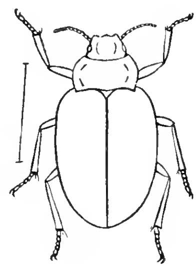
Dytiscus.

FIG. 95.



A Carabid.

FIG. 96.



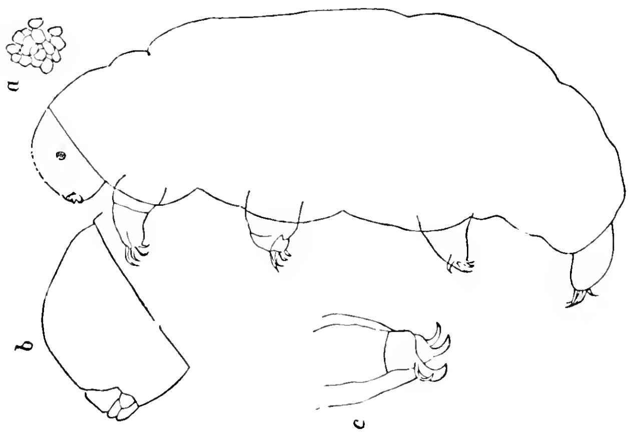
Amphizoa.

which are aquatic are allied to the carnivorous ground beetles. The Dytiscus and its allies are essentially aquatic Carabidæ, the family comprising the ground beetles. The larvæ of these water beetles have the same kind of feelers and mouth-parts as the land Carabids; the structure of the adult beetle is on the Carabid type, the body being, however, more ovate and modified for swimming. Both types (Figs. 94 and 95) may have been derived from ancestors of terrestrial habits. As proof of this we have the Californian Amphizoa (Fig. 96), which is said by Dr. Horn to

be subaquatic, and in its structure and habits connects the Carabids with the Dytiscidæ.

Out of the immense number of species of butterflies and moths, but three or four genera are known to be aquatic. The larvæ of Hydrocampa, Cataclysta and Paraponyx, small moths of the family of Pyralidæ, live in the water on the leaves of aquatic plants, the caterpillar of Paraponyx being provided both with branchiæ and spiracles. M. Bar has lately discovered in French Guiana a hairy caterpillar which

FIG. 97.



A Tardigrade.

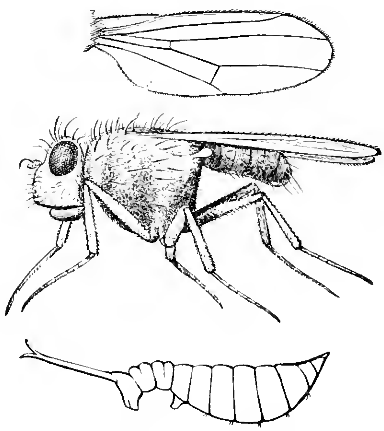
lives in the water, and resembles that of our Arctia or "woolly bear." It has no tracheal branchiæ, and all the spiracles except those on the segment behind the head and a pair on the end of the body are smaller than usual.

There are no truly aquatic Hymenoptera or Orthoptera. The aquatic Hemiptera, such as Gerris, Notonecta, a Corixa and a few other forms, all breathe atmospheric air, though the stigmata may be elongated and otherwise modified for the purpose. One spider, the Argyroneta of Europe, is

aquatic. We know of no other water spider. Certain mites are aquatic, but do not differ from land species in their mode of respiration. The Tardigrades (Fig. 97, *Macrobiotus Americanus*) are low microscopic mites, which live in water and are called water bears. They have no spiracles nor air tubes, and respire solely through the skin. The Pycnogonids, which live at all depths of the ocean, from low water to several hundred fathoms, and which are probably related to the mites, also breathe through the skin.

It is among the two-winged flies (Diptera) and Neuroptera

FIG. 98.



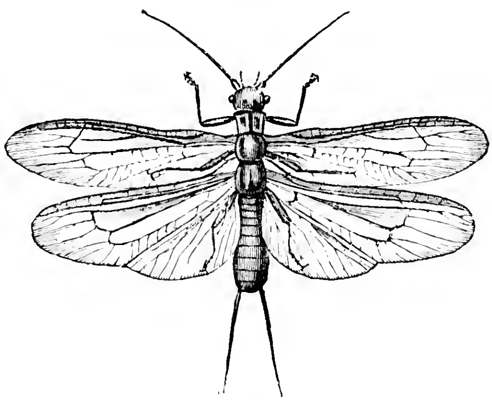
Ephydra and pupa case.

that we find insects with gill-like appendages penetrated by air tubes which supply fresh air to the blood. There are quite a number of aquatic larvæ of flies, but with few exceptions, such as those of the mosquito and black fly, they belong to families which also contain closely allied genera which live in the earth. For example, most crane fly larvæ are terrestrial, a few are adapted for aquatic life; some larval horse flies live in mould, some are known to be aquatic;

most of the Syrphidæ are Aphis-eaters in the larval state. Of that immense family Muscidæ, of which the house fly is a type, which are almost purely terrestrial, Ephydra (Fig. 98, fly and pupa case) is aquatic. It may be said on the whole that the aquatic larvæ of the Diptera were originally terrestrial insects, which have adopted an aquatic life and are exceptions to the rule.

In the Neuroptera, however, there are whole families which are aquatic both in the larval and pupal state, having external gill-like appendages in both stages, and in the case of

FIG. 99.



Perla.

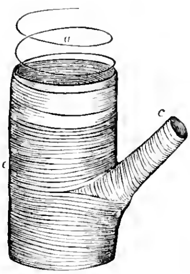
Pteronarcys, which is closely allied to Perla (Fig. 99, from Figuier), they are retained in the winged fly. The Neuroptera are *par excellence* water insects, and yet it is doubtful even whether they have not originally assumed this exceptional mode of life, and, while the earliest of all insects, were not at first terrestrial. This is speculation and guesswork, but facts seem to point to this conclusion.

Now the changes in structure fitting the insect for a life in ponds and streams are to be found in the organs of locomotion and the breathing apparatus, and in this essay I

shall endeavor to show how insects primarily adapted for breathing atmospheric air are enabled to breathe in the water; then I shall notice the various modes of swimming in aquatic insects.

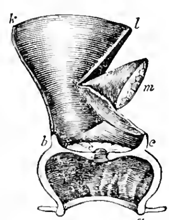
In the first place, how are insects fitted to live under water? It will be remembered that all insects breathe by means of air tubes called tracheæ (Fig. 100, trachea; Fig. 101, section of spiracle). These are tubes composed of three coats; the inner, a tube of mucous membrane surrounded by a spiral thread, formed originally out of a homogeneous membrane which ultimately splits up into these spiral threads, giving rigidity and toughness to the tube. There is a third loose investing membrane, the so-called peritoneal coat. A trachea originates from a spiracle or breathing hole, of which there are usually nine on each side of the body. These spiracles, or stigmata (Fig. 101, *aa*), open by a slit into an inner chamber (*e b*), guarded by a muscle (*m*). The air thus admitted is carried into every part of the body by the numerous fine subdivisions of these tubes, which form a beautiful net-work of silvery threads when filled with air. They are bathed by the blood which is everywhere oxygenated by the air in these fine tubes.

FIG. 100.



Trachea.

FIG. 101.



Spiracle.

Numerous beetles and water bugs have no special apparatus for breathing in the water. The Dytiscus when it wishes to breathe rises to the surface, tail foremost, bends the end of its abdomen so as to allow the air to pass into the spiracles under the elytra, and scuttles down to the bottom in great apparent haste, with a bubble of air attached to the tip of the body. When its supply of air is exhausted

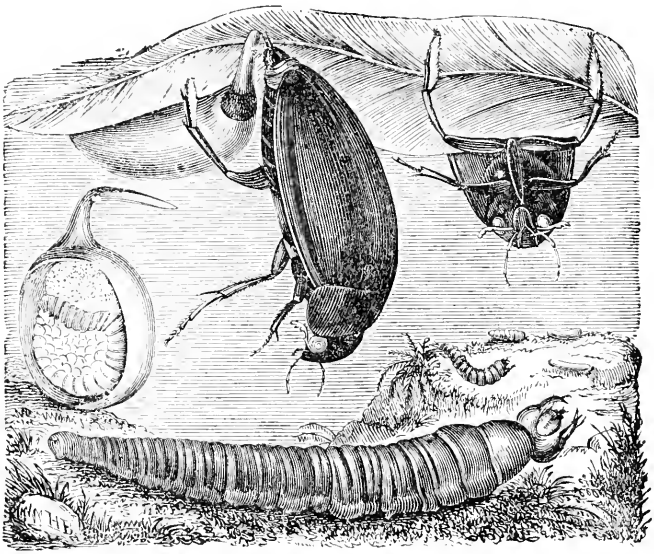
it is forced to rise for more. In the travels of Colymbetes, a near ally of Dytiscus, around the jar in which we have watched its movements, it often makes a squeaking sound, which we have heard at night as often as by day. This noise can be readily produced artificially by rubbing the end of the abdomen against the elytra, or wing covers. In this beetle there are six pairs of abdominal spiracles, but the basal pair are nearly three times as large as the others, and into these most of the air probably enters. In handling this beetle one is apt to be pricked by the sternal spine, which extends back of the insertion of the hind legs and is as sharp as a needle. How useful it may be to the insect in pushing its way through any obstacle may be demonstrated by holding it tightly between the fingers; here even it manages to push its way out and drop to the ground. All the water beetles fly about in the night, exchanging one pond for another, and they sometimes enter our windows.

Siebold says that *Hydrophilus piceus* (Fig. 102, from Figuier), the largest of all the water beetles, and belonging to a different group from Dytiscus, when it breathes, protrudes only its antennæ out of water, and, "bending them backwards, thus establishes a communication between the external air and that adhering to the under surface of the body."

In our *Notonecta undulata* (Fig. 103) the mode of taking aboard its supply of air before diving is most admirable. The deck of the boat, *i.e.*, the under side of the body (for the insect swims on its back) has a longitudinal ridge in the middle; a broad gutter between this ridge and the sharp edge of the body is bridged over from the head to the end of the abdomen by a layer of dark, coarse, oblique hairs, and a layer of less oblique hairs arises on each side from the middle of the ridge. These hairs thus form a false upper deck. The creature rises to the surface, the end of the body projecting slightly out of water; the air passes up on each

side along the tunnel under the hairs and collects in bubbles above the base of the legs. Along the bottom of this

FIG. 102.



Hydrophilus piceus, eggs and larva.

tunnel are six pairs of spiracles into which the air passes. The air in the specimens we observed did not adhere to the hairs of the hind legs as Siebold says it does, nor, as he states in his "Comparative Anatomy," translated by Burnett, does the air for respiration as a rule pass under the elytra, since the spiracles are not situated on the upper side of the body but on the under, and quite a distance from the edge of the body. Nor does this insect breathe at all, as Westwood states, like Dytiscus, in which the spiracles are situated on the upper side of the body, so that the air enters readily under the elytra. When it takes in the air the tip of the abdomen is thrust up just above

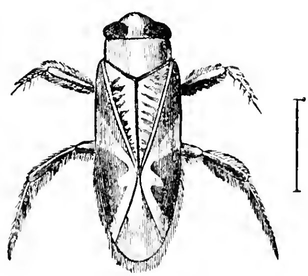
FIG. 103.

Notonecta.

water and an orifice is formed by the separation of the hairs at the end of the keel, which form the larger part of the mouth of the orifice, the remainder being composed of the hairs fringing the movable terminal plates of the body. The air thus passes in between the false deck of hairs and the under side of the body. When the insect is taken out of the water the hairs cling to the sides of the body, revealing very distinctly the breathing holes. Some air occasionally penetrates under the elytra and remains there most of the time. Often the whole under side of the body between the pairs of legs is a continuous bubble, like a mass of quicksilver or molten lead. The Notonecta often rises for a new supply of air before the old is exhausted.

While handling Notonecta thoughtless of its reputed sting, in a quiet business-like way it inserted its beak in my thumb, the pain almost as severe as the sting of a wasp, and lasting for five minutes. The pain was too acute and benumbing not to be the effect of a poison. If no poison sac will yet be found in the head, then the saliva must be an acrid poison. By this poisonous sting it must paralyze its victims.

Fig. 101.



Corixa.

Another water bug, the Corixa (Fig. 101, enlarged), is less tame and does not come to the surface nearly as often as Notonecta. It receives its supply of air in an instant and darts down to the bottom. It does not swim in an inverted position. It takes in the air so suddenly that it is impossible without long and patient observation to see the mode, which we have been unable to find described. It rises to the surface in a horizontal position and no sooner is the surface reached than it darts to the bottom, and in one instance

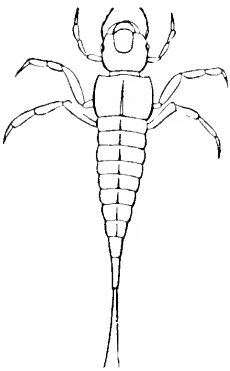
remained there for ten minutes by the watch, and then darted up again, leaving an air bubble in its wake, which rose to the top afterwards. It carries down with it a broad silvery streak along the side of the body. The air is really introduced under the head and front thorax. The head is large and very movable, as well as the prothorax. It slides back and forth on a thin membrane, from the surface of which it can be raised. So with the hinder edge of the prothorax, which rides over the membranous hind thorax, which it nearly conceals. When the Corixa rises to the surface it floats in a horizontal position, the hind edge of the head and the prothorax rising slightly above the surface. Now slightly raising the back of the head and the hind edge of the prothorax a space appears in front of and behind the prothorax, by which the air passes into the breathing holes beneath. This is proved by the small bubbles of air remaining in these two cracks. Two minute spiracles may be detected in deep pits, one on each side, just above the insertion of the legs, and from which the tracheæ arise, each one dividing into three irregular short branches, as may be seen by detaching the segment and holding it up to the light.

So much for those insects which simply rise to the surface and take in air without any special modification of the spiracles. We now come to a second group of adult insects which, by a change in the number, position and form of the spiracles, are provided with a special respiratory contrivance. A striking example is seen in Ranatra, the water stick bug. The end of this creature's body terminates in two thin tubes nearly as long as the insect itself, at the end of which are two spiracles, each connecting with a trachea. These long appendages, which are simply elongated spiracles, it thrusts out of the water, takes in its supply of air, and then goes on in its deliberate ramble. The Nepa of Europe has much shorter respiratory tubes than Ranatra, while those of Belostoma scarcely project beyond the body, though in *B. annec-*

tens, from Nicaragua, they are a quarter of an inch long and two tracheal branches can be distinctly seen in each of them. The other abdominal spiracles are wanting in these three forms, though three pairs, according to Schiödte, are present on the thorax.

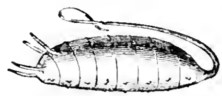
There are a number of aquatic larvæ which breathe by similar respiratory tubes. Such is the young of Dytiscus

FIG. 105.



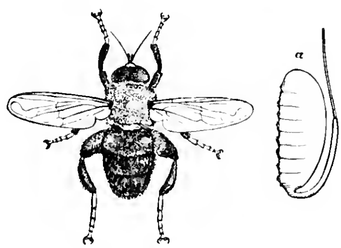
Dytiscus larva.

FIG. 106.



Eristalis larva.

FIG. 107.



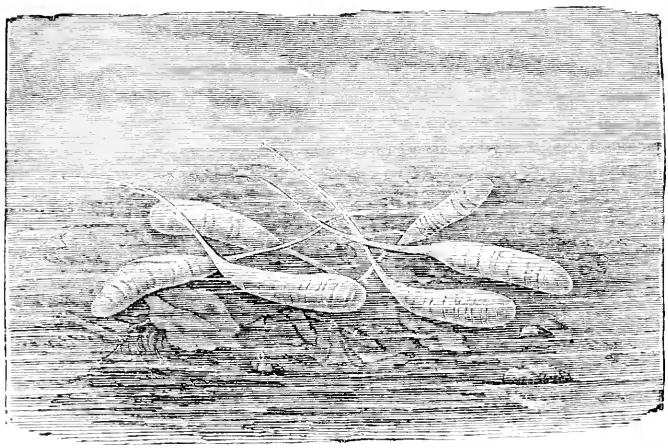
Merodon and larva.

(Fig. 105). It has to rise to the surface for air, which is inspired through the bristle-like tubes at the end of the body. So with the larval Eristalis (Fig. 106), and its ally *Merodon bardus* (Fig. 107; *a*, larva) and Helophilus (Fig. 108). These maggots frequent the most loathsome ditches, thick with mud and putrefying matter. Here they lie acting as scavengers and doing all they can to aid the State Board of Health. They wave their long flexible respiratory tubes aloft and drink in the pure air of heaven, not unmixed, perhaps, with the less than spicy odors emanating from their native puddle. Some of the Helophili frequent strongly brackish water, in fact almost purely salt water, while

Ephydra, with its rather short, thick tubes and fleshy feet, clambers over green sea weeds in salt pools removed above the reach of ordinary tides, or lives in the brine pools of Illinois, or the salt lakes of the West. The aquatic larva of one of the Tipulids or crane flies (Ptychoptera) has a long respiratory tube, while in the pupa there is one attached to the head and much longer proportionally than in the larval Helophilus.

Among those larval flies which are obliged to ascend to the surface to breathe, is the young Mosquito (Fig. 109; A,

FIG. 108.

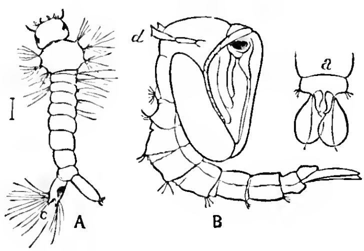


Helophilus larvæ (after Figuier).

larva; B, pupa; *a*, paddles at end of body of pupa). Its body is beautifully adapted for going through its aquatic evolutions. The head and thorax are so large and bulky that it cannot ascend and lie motionless in a horizontal position, as in the young Anopheles, which lies before us in a dish as we are writing; but it hangs head downwards and breathes by means of a spiracle lodged in one of the large tubes into which the end of the body subdivides, the posi-

tion of this tube being maintained by a pencil of radiating hairs, attached to a shorter projection at the end of the body. The air is rapidly absorbed by the unusually large trachea, nearly filling the longer tube. After taking a fresh breath it often swings its head around, mouth upwards, its tail being the pivot, mowing the surface of the water, if clouded with decaying matter, with its jaws. The young Anopheles, the fly of which is the four-spotted mosquito found in houses late in autumn and early in spring, is a surface breather. But the head and thorax are scarcely heavier than the hind body, and along its whole length are tufts of hairs which spread out and act as floats to the body. The mouth-parts are tufted more distinctly than in the

FIG. 109.



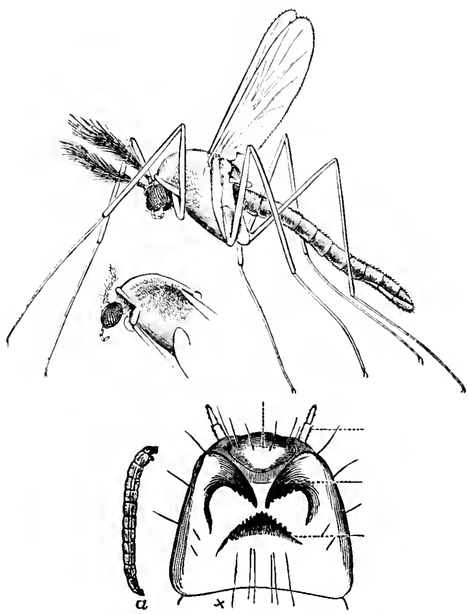
Mosquito larva and pupa.

young mosquito. In this larva the body ends in four fleshy finger-like appendages, in which the tracheæ may be distinctly seen.

In its pupal stage the mosquito is quite a different being. Its life is regulated by a new code. It scorns food of all sorts, and like some religious devotee lives on air alone, and that in homeopathic doses. The enormous thorax is almost a deformity, and now, instead of breathing through its tail, it bears two club-shaped respiratory tubes on its back (Fig. 109, *d*). These are situated on the site of the future thoracic spiracles of the fly.

Of those insects which extract air from the water in which they live and are not obliged to ascend to the surface, is the young of the plumed gnat (Fig. 110, *Chironomus oceanicus*, male, and beneath, head of female; *a*, larva and head enlarged). These worms are very abundant in every mud puddle, but the species here figured lives at all depths in

FIG. 110.



Ocean Gnat; *a*, larva, and head enlarged.

the sea down to over a hundred feet. Some larvæ of another species were dredged in Lake Superior by Mr. S. I. Smith at a depth of one hundred and fifty-five feet. They are usually provided with two pairs of fleshy filaments, permeated by one or two slender tracheal twigs, connecting with a slender pair of tracheæ running through the body, and

enlarging towards the head. So slightly developed, however, is the tracheal system in Chironomus, and so thin are the walls of the body, that I am inclined to think that these nearly transparent larvæ breathe in part through their skin.

Now we have in the singular ghost-like larva of Corethra another plumed gnat, a being which has no spiracles nor tracheæ, and which breathes, as Weissmann says, through the skin. The air thus absorbed is contained in four reservoirs, forming swimming bladders, and thus the density of the water is measured by this living hydrostatic apparatus. Two of these kidney-shaped bladders are lodged in the thorax and are larger than the two near the end, in order to support the heavier front end of the worm. These singular larvæ may be found in winter in ponds by breaking through the ice, as well as the Belostoma and various water beetles, and can be kept alive in jars of water.

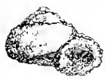
The finger-like appendages we have described in the larva of the plumed gnat afford the simplest form of "tracheal gill." Did the blood penetrate into them and accompany in closed vessels the air tube, it would be exactly comparable with the gills of fishes and larval amphibious reptiles; but it does not; it is not a true gill, and the term "false gill" or "tracheal gill" has been applied to this organ.

From the young Chironomus, with its four tracheal finger-shaped gills attached to the extreme end of the body, we may pass to a singular larva of a European crane fly, called Cylindrotoma, which according to DeGeer breathes by means of numerous hollow flexible filaments scattered over the body, and which, as Westwood says, appear to be traversed by tracheæ. A similar looking creature is the caterpillar of Paraponyx, which respires under water by means of a number of fasciculate filaments situated on the sides of the abdominal rings.

In fact this caterpillar has been anticipated by the case worms, the young of the Caddis flies, in which the caterpil-

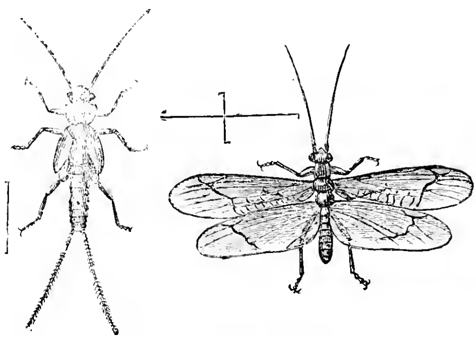
lar-like body is provided with white, slender filaments, arising in groups of from two to five and crossing over the back of the worm. When the case worms are about to transform they close up the mouth of their case with a grating, or, as in the snail-like case-worm (Helicopsyche), whose case (Fig. 111) is made of grains of sand, they close the aperture by a dense silken lid, pierced by a slit through which the water enters. The only exception known to this mode of respiration in the large family of Caddis flies is Enoicyla, which is terrestrial, living in moss at the roots of trees, and consequently has no respiratory

FIG. 111.



Case of Helicopsyche.

FIG. 112.



Nemoura and pupa.

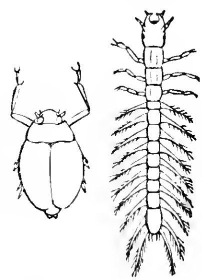
filaments. Notwithstanding the submerged life of these case worms, they are attacked by ichneumon flies when in the larval state. How the young ichneumon lives in the submerged body of its host is not known.

The branchial gills in the Perla and its allies, Nemoura (Fig. 112, and pupa) and Pteronarcys, etc., which are flat-bodied insects living under stones in streams, have been investigated by Newport, the famous English anatomist, and quite recently by Dr. Gerstaecker of Berlin. Mr. Newport made the astonishing discovery that the winged adult Ptero-

narchys retains its larval tracheal gills, and Dr. Gerstaecker has lately discovered that this is also the case with a species of Diamphipnoa from Chili, and a European species of Nemoura. This is analogous to certain Tritons or Salamanders which retain their gills in adult life.

The larva of Hydrophilus, the large water beetle (Fig. 102), breathes by means of spiracles, but is probably aided by the lateral filaments along the abdomen. One would hardly suspect that the whirligig beetle which gyrates almost unceasingly on the surface of every roadside puddle or eddy of the stream, had young of such a singular appearance. They differ from all known coleopterous larvæ in the possession of eight pairs of large, long, thick, hairy appendages permeated by tracheæ. They would by some be mistaken for caddis worms, but their head is much larger and jaws much longer and sickle-shaped. In August the mature larvæ are said to creep out of the water and spin an oval cocoon attached to some plant, and then dropping their tracheal gills, with their larval skins, breathe through spiracles. After remaining a month in the pupa state it appears as a beetle, which lays its eggs in regular rows on the leaves of water plants, and in about a week after the larvæ are hatched.

FIG. 113.

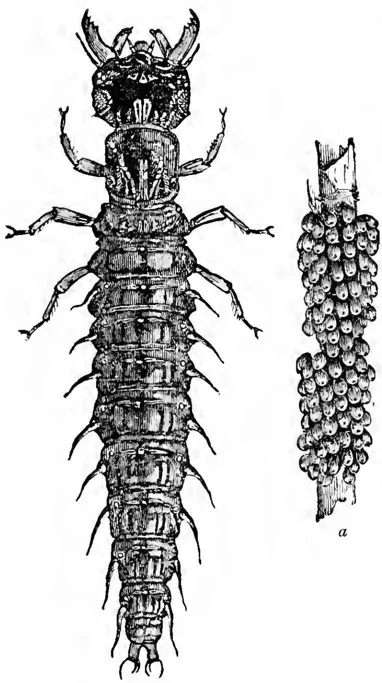


Gyrinus and larva.

An interesting chapter might be written on the sense of sight in aquatic insects. In Notonecta and Corixa the eyes pass under the water level, so that they can see above and below at the same time. So with Gyrinus (Fig. 113). Its eyes are divided by the portion of the head that carries the antennæ, so that, as Wood says, the portion under the surface may be compared with a water glass used by fishermen for observing objects at the bottom. Our Gyrinus larva repeats with great exactitude the form of the young Cory-

dalus (Fig. 114), which transforms into the large net-veined insect (Fig. 115) so formidable in appearance, and yet so harmless. A singular chapter in biology would be the life of this insect. The gigantic carnivorous larva, with its large head and enormous jaws, is provided with eight pairs of long, rather stiff, respiratory filaments. Dr. Hagen has called attention to the spiracles of this creature, which are not usually present with tracheal gills, and to the reason for their existence. It seems that like the European Sialis (Fig. 116, larva and pupa) it lives some weeks out of water before its transformation into the pupa, which rests in an earthen cocoon in the banks of streams above water. The eggs (Fig. 114, *a*) are very large, and are deposited in a squarish mass on the stems of water plants.

FIG. 114.

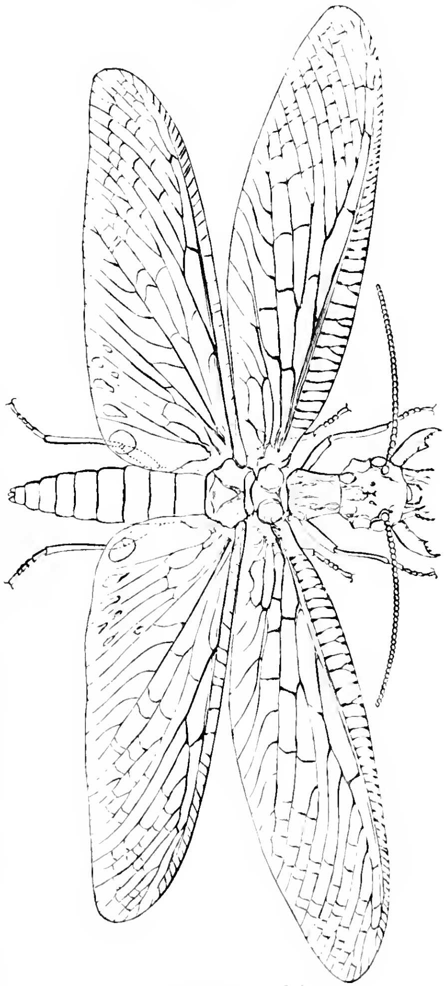


Corydalus larva and eggs.

There is no more beautiful object for low powers of the microscope than the larval May fly (Fig. 117). The body is so transparent that the movements of the heart, the play of its valves, the circulation of the blood, the distribution of the tracheæ, the digestive canal and its movements, as well as the action of the

muscles controlling the jaws and other parts of the mouth, can all be watched with ease. The tracheal gills, like paddles, either round or long and leaf-like, are arranged in pairs along the hinder region of the body, and the tracheæ in them can be readily seen. These beautiful respiratory leaves are also paddles, and by their aid as well as by the undulations of the body the young May fly moves rapidly and gracefully through the water. It lives two years, while the winged fly (Fig. 118) but a day, rarely over twenty-four hours. The winged fly throws off the pupa skin in an instant. While holding a pupa in my hands the imago slipped out suddenly with wings fully formed. This

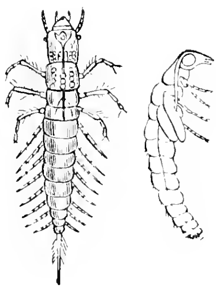
FIG. 115.



The Horned Corydalus.

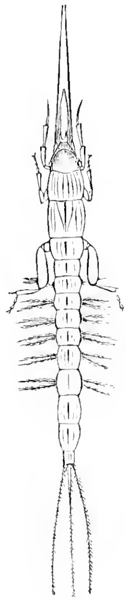
was the so-called sub-imago; after a few hours, if it had not been placed in the collecting bottle, it would have thrown off a thin pellicle, and then been sexually mature. It then

FIG. 116.



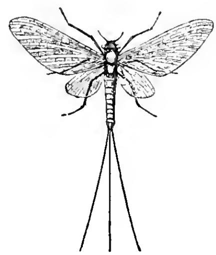
Larva and Pupa of Sialis.

FIG. 117.



Larva of Palingenia.

FIG. 118.



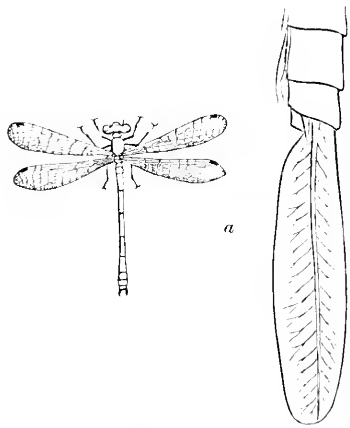
May Fly.

lays its eggs in a round mass and dies. Some of the larvæ live in burrows at the bottom of ponds, while others swim free.

Coming, lastly, to the family of Dragon flies, we find among the larvæ the most diverse means of respiration. In the young of Agrion (Fig. 119; *a*, respiratory leaf of larva) the body ends in three large leaves, through the middle of which runs a trachea which sends off a number of smaller branches. These larvæ when quite small are beautiful ob-

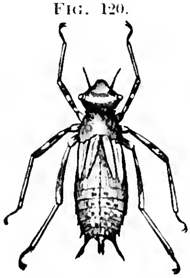
jects for the microscope, their bodies then are so transparent. Now in the young of the larger dragon flies, such as Diplax, Cordulia (Fig. 120), Æschna (Fig. 121), and Macromia (Fig. 122), the breathing process is carried on within the body. The terminal portion of the digestive tract is provided with ridges of mucous membrane. Into these folds or ridges numerous tracheal twigs penetrate (Fig. 123, *x*). The water is admitted through the conical valves at the end of the body; there it is deprived of its air, which is absorbed by the tracheæ and ejected in a gentle stream, or, if the creature is startled, it is driven out as if by a force pump or syringe, sending the insect forward several times its own length.

FIG. 119.



Agrion and Respiratory Leaf of Larva.

FIG. 120.



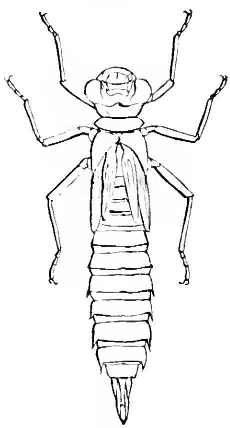
Cordulia lateralis.

Returning again to the May flies, Walsh has described a mode of respiration unique in that group, but which reminds us of the internal lung-like apparatus of the larval dragon fly. This curious form is otherwise an exception to all insects, in that its three thoracic rings above are, instead of being separate, consolidated into one plate which extends back half-way over the abdomen. Fig. 121, III, shows the position of the tracheal lungs in the end of the abdomen. We need further observations to show how the animal takes in and expels the water.

No Myriopods are aquatic, but a number of mites and allied forms live in water and extract the air mechanically mixed with the water, without having to rise to the surface. They have two spiracles and air tubes, but how they extract the air in the water is not known. Such are the Hydrachna and Atax, which live in their early stages as parasites between the gills of fresh water clams, while some species attach themselves to water insects.

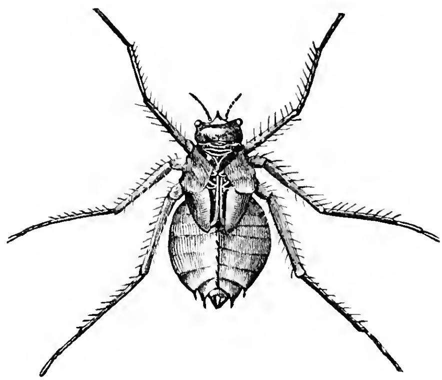
Of the various modes of swimming among insects, the

FIG. 121.



Æschna.

FIG. 122.



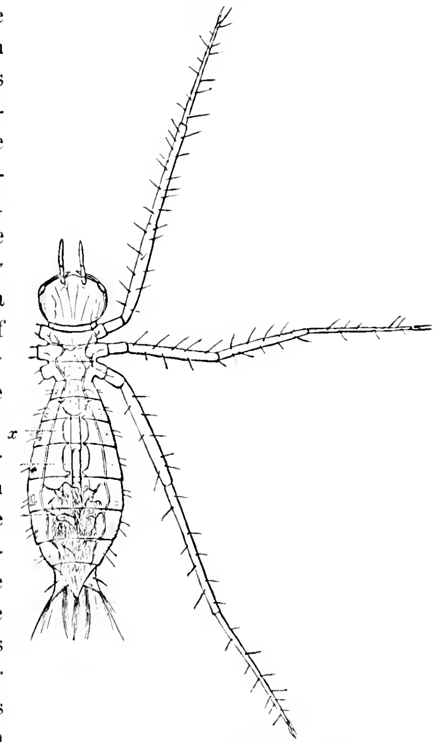
Macromia transversa.

simplest, though not the most graceful, is wriggling. By a series of contortions of the body the young Chironomus moves about without much apparent purpose. The twistings and turnings of the larval mosquito are anticipations in nature of the most laborious and complicated feats in gymnastics of the circus clown. The latter realizes the amount of muscular exertion and nervous strain expended in a two-minutes circumtorsion of the ring. The young mosquito, through its life of such violent undulations, knows no fatigue. A study, through the transparent skin, of the arrangement

of the muscles of the body shows their wonderful adaptability for the production of these complicated movements.

Many aquatic insects are either "side wheelers" or propellers. The larval Ephemera, aided by the beautiful paddle-like tracheal gills along the sides of the body, moves through the water by a series of exceedingly graceful undulations; while the young Agrion propels itself, partly at least, by its large terminal respiratory leaves. How by a strange economy of nature the dragon fly larva combines the functions of digestion, locomotion and respiration in an organ which like a force pump ejects a powerful stream, and like a flash propels the creature many times its own length over the bottom of its pond, we have seen above.

FIG. 123.



Diplax larva; *x*, mass of tracheæ.

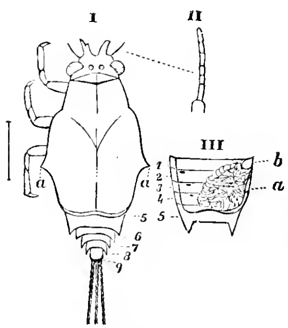
One important result of the metamorphosis of the young mosquito into a pupa is that it is promoted from a wriggler to a paddler, paddling being a higher mode of aquatic locomotion. Our figure of the pupal mosquito shows in a rude way the two beautiful, thin, rounded paddles at the end of

the body. By dexterous strokes, aided by a graceful but rapid bending of the body, it seeks the surface and inspires air through its thoracic respiratory tubes. In the same way it descends to the bottom.

The Corethra larva alters the specific gravity of its body during the course of its wriggling, but as a pupa all this is changed. It now resembles the mosquito pupa, has external thoracic respiratory tubes and well developed tracheæ; it loses its air bladders and swims by means of two terminal paddles like those of the mosquito.

We now come to the water beetles and bugs, whose movements in the water are as graceful as they are awkward on land. Their whole organization, bodily and psychical, as thoroughly adapts them for the water as that of the seal or whale for the same element. They are the Amphibia of the insect world. Born as sailors, they take to the water on being hatched and there remain through their lives, only leaving one pond to seek another, impelled by a restless love of change, which unconsciously to themselves results in good to their race, preventing too close in-and-in breeding and the consequent deterioration of the stock. Look at the body of the Dytiscus (Fig. 125), so perfectly adapted for its aquatic life. Remember that it is in reality a modified ground beetle, such as Harpalus, the mouth-parts much the same, and that the changes in form are mostly, if not wholly, such as adapt it to its aquatic life. The body is oval, both ends alike, as in a boat, while the legs are perfect oars. The hind legs, instead of being broad and spiny towards the claws, as in the running ground beetles, taper to a point

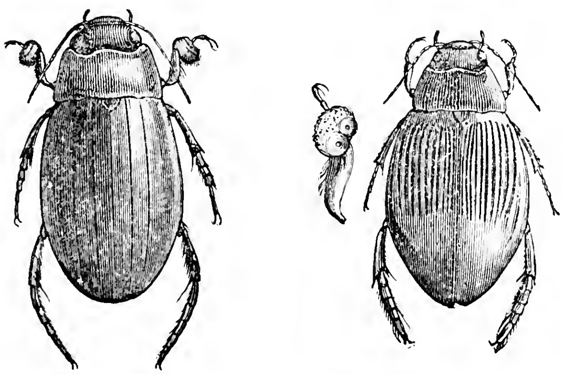
FIG. 124.



Bætisca.

and are articulated by an exquisite mechanism to the body. They are edged on the inner side with a dense, long fringe of exceedingly fine, white hairs, forming, with the flattened leg itself, the blade of the oar; and thus by a series of rapid strokes the body is propelled onwards. The fore legs are short and thick, and in the males modified into a clasping organ, the three basal joints of the tarsus being broadly dilated and consolidated into a large disk, covered with "many minute funnel-shaped suckers, two or three of which are much larger than the others." The Gyrinus is less a

FIG. 125.



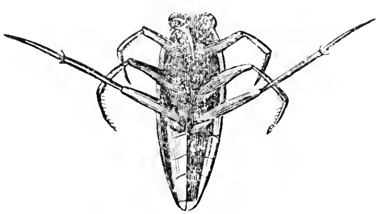
Male and Female Dytiscus.

diver than a surface swimmer. It is a very sociable insect, forming little swimming parties on the surface of the water. In the course of its gyrations it manages to pick up a comfortable livelihood of small beetles and flies which fall into the water. When disturbed it dives to the bottom. Unlike the other water beetles it has very large fore legs and remarkably short middle and hind legs, and flies about in the night, at daylight slipping quietly into some pool. On being handled it emits a disagreeable, whitish, milky fluid, which is probably distasteful to its enemies. All the other

water beetles, so far as we have observed, secrete a similar fluid, but in less abundance.

Equally, if not more, perfect in its adaptability to aquatic life is the Notonecta, which, as its name implies, swims on its back. Now look at the form of the body. The back, usually broad and flat in the Hemiptera, is here rounded like the keel of a canoe, while the under side is flat, forming the deck of the boat, to which the oars are attached by a set of automatic row-locks. The head is bent over and submerged in front; the eyes are partly above and partly beneath the water, so that a double outlook into two worlds is secured. The antennæ are tucked away out of sight in a groove under the eyes. The end of the body is pointed, affording no resistance to the water, and the posterior half of the body is fringed with long spreading hairs, which aid in buoying the body up. The adjoining cut (126) gives an idea of the attitude of the Notonecta when at rest at the surface of the water, back downwards. The hind feet are beautifully fringed, and while swimming it feathers its oars, the hairs of the blade being pressed to the leg as it is drawn forwards, and again spreading out with the backward stroke of the limb. In this insect, as well as in Corixa, as Schiödte observes, the hind legs are moved both together, as in Dytiscus. In Belostoma, and probably Ranatra, they are moved alternately. When about to fly from its pool, which it does by day as well as by night, as is the case with Corixa, it dives a little way down, and then leaps suddenly straight up out of the water, and spreads its wings, flying rapidly off. All the water bugs and beetles are careful to keep themselves clean and smooth. Particularly necessary is it for

FIG. 126.



Notonecta.

the Notonecta to keep its keel smooth, and it may often be seen brushing its back with its hind legs, or where they will not suffice, using the middle and front legs for this purpose. It lays its long, cylindrical eggs on the stems and leaves of plants. The young hatch in about fifteen days, appearing in spring. They differ from their parent chiefly in wanting wings.

Corixa is in its form more like the slow moving punt, being rounded nearly alike at both ends. The head is still more bent and prolonged beneath, partly overlapping the thorax. Its beak is minute and hidden from sight.

So much for the swimming insects, of which we have mentioned the principal forms. There are a few of what may be called *skaters*. They move like the Wherryman, or Gerris, on the surface of the water, their feet being so constructed as to enable them to run upon the surface without wetting them. The middle pair of feet are longer than the hinder, and they mostly perform the work of skating, being covered with fine hairs which repel the water; and thus the insect skims over the surface with great rapidity, making very short twists and turns like a practised skater. The under side of the body is covered with short hairs like plush, forming a repellent surface to the water.

The fore limbs are much shorter and used at times in retaining their prey. Some of these Wherrymen will be found minus the hind wings, and are condemned to a life of comparative seclusion; though it is said that the winged individuals seldom take flight.

Far out in mid ocean in the tropics are found the oceanic water-skaters, the Hylobates. Their fore legs are short, outstretched, with thickened thighs. They are also wingless, the wing-covers alone being present. They course over the surface of the ocean in large swarms, and are seen from vessels many hundred miles from land. They are the true "toilers of the sea" among insects.

The only possible way to study the aquatic insects is to keep them in glass jars and bowls, where their habits can be carefully studied. An aquarium may thus be improvised which will last for several weeks without care, though it is better to add a few water plants, such as the water cress, the Valisneria, Callitriche, Duckweed and other plants, to keep the water oxygenated. By stocking the aquarium with the larvæ and pupæ of certain neuropterous insects at the time when the winged forms are most abundant, the immature forms can easily be kept long enough for us to determine the winged species into which they pass. In the autumn, as cold weather and short days keep us indoors, much profit and solid amusement may be gained by these studies of pond life within the house. Even in winter after the snow is on the ground, one can break through the ice of roadside ponds and with a small net capture nearly all the insects we have spoken of in this number, and keep watch upon their habits, and study their anatomy, with the aid of the needle and lens. He can also turn to the lower forms, such as the water fleas, rotifers, infusoria and rhizopods, with which the waters teem winter and summer, and find, with a few dips of the net, material for weeks of observation and study.

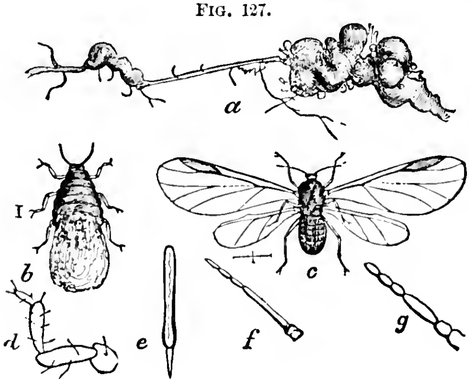
7. The Population of an Apple Tree.

A FRENCH author has written a very pleasant little book entitled the "Population of a Pear Tree." Of the population of an apple tree a ponderous tome could be written, but in this essay on the insects injuring this *facile princeps* of our fruit trees, we shall confine ourselves mainly to the more injurious kinds, giving a brief and condensed account of the most important species. About seventy-five species in all are known to prey upon the apple tree. We may first consider those kinds found

PREYING UPON THE ROOTS.

The Pear Blight, or *Eriosoma pyri* (Fig. 127; *a*, the gall; *b*, larva; *c*, female; *d*, leg; *e*, beak; *f*, antenna of female;

FIG. 127.



Blight Insect.

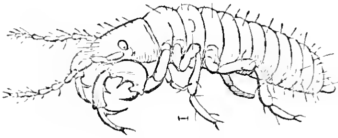
g, of larva; after Riley) sometimes causes a good deal of disturbance to the health of the tree, lessening the vigor of its growth and causing the leaves to turn of a paler and more yellowish hue than usual. If there is no borer under

the bark, nor any other apparent cause, and if it be a young tree, it may be found on removing the soil from the roots that a number of gall-like excrescences, sometimes a couple of inches in diameter, are attached to them. On opening the galls a number of small wingless plant lice, with larger winged ones, will be observed in the crevices. Their bodies are covered with a woolly exudation, whence their common name, "woolly blight." Dr. Fitch, who has given us the best account of this annoying blight insect, says that the parent insect at the end of autumn works her way down along the side of the root, there depositing her stock of eggs, and then, the grand aim of her life accomplished, she dies. When the ground becomes warm in spring the young appear and forthwith plunge their beaks into the bark. The beak thus inserted acts like a seton in the flesh of an animal, and keeps up a constant irritation. An abnormal cell-growth sets in, bringing about a permanent enlargement, which undermines the health of the tree. It is especially injurious in nurseries of young trees.

Dr. Fitch wisely recommends that when the tree is found to be infested, it should not be thrown away, but the roots should be dipped in soap suds, and when replanted a shovelful of ashes should be mixed with the dirt. This insect is a near ally of the famous Phylloxera of the vine.

Another insect not usually suspected of injuring the apple by sucking the sap of the roots is the young of the Cicada (Fig. 128, enlarged), which lives for sixteen years sucking the roots usually of the oak, but is sometimes liable to attack the roots of the apple. It may be imagined that sixteen years' drainage of the sap of the tree is a pretty serious matter. The young insect lives a foot or two beneath the surface of the

FIG. 128.



Young Cicada.

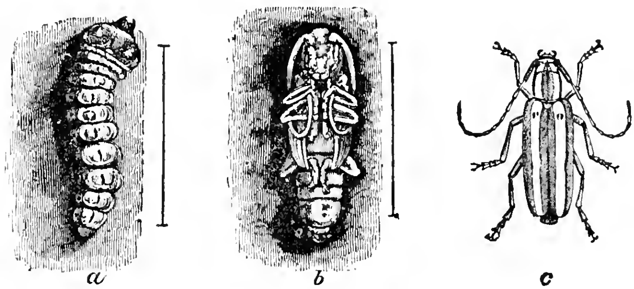
ground. The Cicada also at times breaks off the twigs of the apple in laying its eggs in them.

INFESTING THE TRUNK OF THE TREE.

The Apple Tree Borer.—It is not particularly creditable to our fruit growers that the apple tree borer still maintains such a sway in our orchards, and that we pay an annual tribute of trees and apples which, were its value set forth in figures, would appall the orchardist. The borer is the most widely extended and wholesale in its destruction of all the insects which prey upon the apple. The canker worm is local, and even then less injurious, taking only the leaves and apples, but leaving the trees. So with the tent caterpillar and bud worm; but the "borer" has almost finished its work of destruction and the tree is doomed, ere we have read its death-warrant. The history of this beetle is as follows: during the night and sometimes in the hottest days of the first week of July, in New England, and in May and June in the western states, the female beetle flies around the trunk of the tree, and during this period she deposits her eggs in the bark near the root of the tree. How many eggs she lays at one time is not known, but she deposits "one egg in a place upon the bark, low down, at or very near the surface of the earth; but when these beetles are numerous, some of their eggs are placed higher up, particularly in the axils where the lower limbs proceed from the trunk" (Fitch). About a fortnight after the eggs are laid the young grub hatches, and immediately begins to eat its way upwards (according to Harris) or downwards (according to Fitch). This grub is a little footless white worm, with the segment next to the head large and thick, and only differs in size from the fully grown worm (Fig. 129; *b*, pupa; *c*, beetle, after Riley). Says Dr. Fitch, "If the outer dark colored surface of the bark be scraped off with a knife the last of August or forepart of September, so as to expose the clean

white bark beneath, as can easily be done without any injury to the tree, wherever there is a young worm it can easily be detected. A little blackish spot, rather larger than a kernel of wheat, will be discovered wherever an egg has been deposited, and by cutting slightly into the bark the worm will be found. It gradually works its way onwards through the bark, increasing in size as it advances, until it reaches the sap-wood; here it takes up its abode, feeding upon and consuming the soft wood, hereby forming a smooth, round, flat cavity, the size of a dollar or larger, immediately under the bark. It keeps its burrow clean by pushing its excrement out of a small crevice or opening through the bark, which it

FIG. 129.



Apple Tree Borer.

makes at the lower part of its burrow, and if this orifice becomes clogged up it opens another. This excrement resembles new fine sawdust, and enables us readily to detect the presence of the worm by the little heap of this substance which is accumulated on the ground, commonly covering the hole out of which it is extruded, and by particles of it which adhere around the orifice when it is higher up, or in the fork of the tree; the outer surface of the bark also often becomes slightly depressed, or flattened, over this cavity."

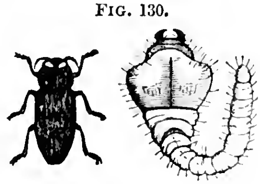
When half grown it sinks into the solid heart wood of the tree and obliterates the flat cell, filling it up with its casting,

and lives in a cylindrical hole; it then ceases to eject its castings, simply pushing them behind it. According to Riley, it is within a few days of three years old before it is ready to change to a pupa, instead of two, as generally stated. Before it becomes fully grown it leaves the heart of the tree and makes its way to the bark, just beneath which it transforms, making a rude cocoon of chips eight or ten inches from its starting point. It pupates late in the spring in May, and appears in June and early in July. The beetle (Fig. 129, *c*) is a brown beetle with long antennæ, with two distinct white stripes. Its primitive home is the June berry and mountain ash, while it also infests the hawthorne, wild apple, the quince and sometimes the pear.

Having become acquainted with the habits of the insect, we are prepared to deal in an intelligent way with it. When the tree is found to be badly infested the readiest way is to cut the worms out, or pour in boiling water. In the autumn the bark should be carefully examined and the young worms be dug out. The best preventive measure is to apply soap to the trunks of young trees in June, or in May in the western states, and surround the trunks with tarred paper. This will baffle the beetle in laying her eggs.

The Buprestid Borers.—Two beetles of this family infest the trunk of the apple in their larval stage. They have hard bodies with a rough exterior, and have the power of snapping up in the air when placed on their backs.

FIG. 130.



Chrysobothris.

The most common is *Chrysobothris femorata* (Fig. 130, natural size; *a*, larva). The grub is much flattened behind the head, forming a rounded expansion, behind which the body is slender and cylindrical. This is the characteristic form of the larvæ of this extensive group of borers. The grub lives a year under the bark of the apple and oak. The beetle is

greenish black above, with a brassy line especially on the raised transverse spots. It may be seen from May until July sunning itself on the bark of the trees in the crevices of which it inserts its eggs. As in the common borer just described it gnaws its way into the heart of the tree, but it only lives over one summer. From the flattened form of its body it makes a broad, flat, and not a cylindrical hole, like that of the common borer, the gallery a little over an inch in length leading upwards from where the young larva began to work. A very similar species, *C. Harrisii*, or Harris' apple borer, is sometimes very destructive to the apple, though the red maple seems to have been its original home. The same remedies should be applied in dealing with these borers as with the young of the striped beetle.

The white-lined Psenocerus.—Though this beetle in the larva state is more commonly found tunnelling the stems of currant bushes, and sometimes boring into grape stems, yet it has been known to be injurious in apple orchards. The beetle is a "longicorn," with a very round, cylindrical body. It is dark reddish-brown, with a swelling at the base of the wing-covers, an oblique yellowish white line on the basal third, and a broad curved white line on the outer third of the wing-cover. The grub (Fig. 131, enlarged about three times) is nearly half an inch in length, with a honey yellow head scarcely half as wide as the body, while the segments of the body are rather convex, each having two rows of minute warts. It devours the sap wood and inner portion of the bark and also the pith of the branches, thus locally killing the terminal twigs, and causing the bark to shrivel and peel off, leaving a distinct "dead line." Each grub lives in a burrow about an inch and a half long, and five such burrows occur in a portion of the branch five inches long. The grubs become fully grown during the middle of August. Dr. Fitch

FIG. 131.

Psenocerus.

says that about the first of June the female deposits her eggs. The grubs change to chrysalides early in the spring, and in New York the beetles appear early in May.

The Cylindrical Bark Borer, or *Tomicus mali*, produces a disease like fire-blight, causing the bark to shrivel and peel off and killing the branches. Dr. Fitch states that young, thrifty trees when attacked by this beetle soon after putting forth their leaves in the spring suddenly wither as though scorched by fire, the bark becoming loosened from the wood, and soon after numerous perforations like pin holes appear, revealing the secret of the sudden destruction befalling the tree. All these bark boring beetles have a common form, that of a cylinder squarely docked at the end, looking as though they had been made by the inch and then cut up into lengths of about a line each. The body is covered over with fine hairs, so that it acts as a brush, like those used for cleaning lamp chimneys. The end of the body is sometimes scooped out like a gouge, so that the little beetle can shovel out the dirt from its house in a true Milesian fashion. The use of the hairs undoubtedly is seen when the insect lays its eggs. The female beetle tunnels a hole in the bark and makes little notches at intervals, in which it deposits an egg. On her return, by means of the short stiff hairs projecting from her body, she brushes the dirt into the little notches, thus covering up and protecting her eggs. Figure 132 represents the *Tomicus xylographus*, enlarged several times. This is a timber beetle, and there are several allied forms, but all are much like the apple bark borer. It seems from the observations of M. Perris, as quoted by Dr. Fitch, that the bark boring beetles, *i.e.*, those infesting fruit trees, differ from the timber beetles in an interesting peculiarity. In the bark beetles there is a division of labor, the males doing most of the work. "There are commonly several males in company with but

FIG. 132.

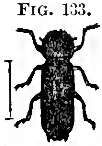
Tomicus.

one female, and the former appear to perform the chief part of the labor in the excavation of their galleries. With the timber beetles, on the other hand, the females are much the more numerous, and probably mine their galleries without any assistance from the other sex. M. Perris states of one of the species, that upwards of fifty females were met with in the burrows they had excavated, without a single male being found there."

As the young hatch out they run galleries either at right angles to the original one, or branching out in every direction, though never intercrossing. In this way those that confine themselves entirely to the sap wood and inner bark loosen it, interrupt the circulation of sap and kill the branch affected.

The Apple Twig Borer or *Amphicerus bicaudatus* (Fig. 133) is an exceedingly annoying beetle in the middle and western states. It somewhat resembles the bark boring beetles, but belongs to a different family. The grub is not known with certainty to burrow in the apple, but the beetles late in the summer bore into the twigs of the apple, beginning, according to Riley, just above a bud or fork, whence it bores downwards an inch and a half into the twig, usually in wood of the previous year's growth. "Both the male and female beetles bore these holes, and may always be found in them head downwards during the winter and spring months. The holes are made for food and protection, and not for breeding purposes." As a preventive measure the infested twigs should be cut off and burned, the trees being looked over in the autumn.

FIG. 133.



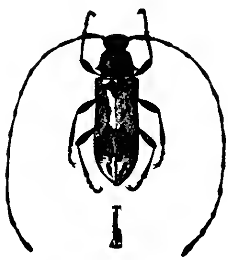
Amphicerus.

The Prickly Leptostylus is the last borer which we have on our list of boring beetles. Dr. Fitch says that the grubs are like the young of the apple tree borer, and sometimes "occur in multitudes under the bark, forming long, narrow, winding tracks upon the outer surface of the wood, these

tracks becoming broader as the worm has increased in size." The beetle appears late in August in New York. It is a brown beetle, its wing-covers prickly, whence the name *Leptostylus aculiferus*, and with a white, curved or V-shaped band behind the middle of the wing-covers, and a black streak on their hind edge. It is about a third of an inch long.

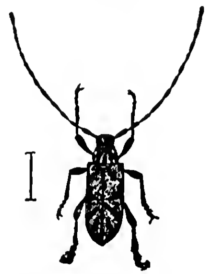
The Apple Leiopus (Fig. 134) is a new comer in our orchards, having lately been found in all its stages of growth

FIG. 134.



Apple Leiopus.

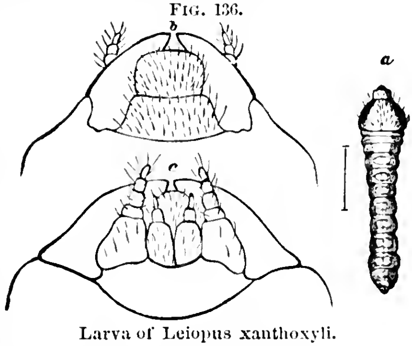
FIG. 135.



Leiopus of Prickly Ash.

in the rotten limbs. The grub is so closely allied to that of another species, *Leiopus xanthoxyli* (Fig. 135, beetle; 136, *a*, larva; *b*, head seen from above; and *c*, seen from beneath), that a wood-cut drawing will answer for both. It differs mainly in having a smaller head and a slenderer body. It seems from what little we know of the habits of these insects that there is probably but one brood of beetles a year, and that they fly about and lay their eggs on the bark of the tree late in June, and probably

FIG. 136.



Larva of Leiopus xanthoxyli.

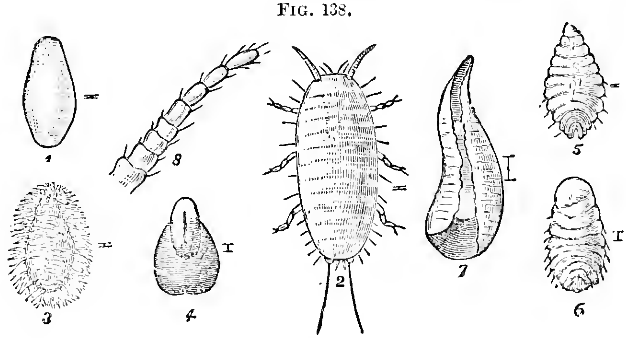
during July. Upon hatching, the young larvæ bore in under the bark, and become fully grown in the autumn, spending the winter under the bark, probably both in the larva and pupa states, the beetles appearing during midsummer.

FIG. 137.

Scale Insect, natural size.

The Scale Insect, *Mytilaspis pomorum* (Bouché) or *Aspidiotus conchiformis* of different authors, Fig. 137.—This, next to the borer, is by far the most prevalent and destructive enemy of the apple tree. The scale surrounds the body of the female, while the male is two-winged and flies about actively. It closely resembles the Pine scale insect figured on page 39. The female lays her eggs (Fig. 138, 1) in August under the scale protecting her body, and the young (2) hatch out in June, when they may be found running over the bark. By the middle or last of the month they become anchored by their long hair-like beak, and the day after, as Riley states, a white waxy secretion begins to issue from the body, as seen in 3. During a period from the 6th to the middle of July, the larva loses

FIG. 138.



Apple Scale Insect.

its legs and feelers and assumes the form of the adult female (5). Soon after the insect moults, and its cast skin remains

attached to the insect as at 4. By the first of August the growth of the scale insect is completed, and it has the appearance of an oyster shell, as seen at 7. By the middle of August in the western states, where Mr. Riley studied its habits, the female lays her eggs, which do not hatch till the following June. It will be seen that the best method of warding off the attacks of this pest is to thoroughly scrape the bark of the tree in the early autumn and again in the beginning of June, when the young are swarming over the surface of the bark. At this time the bark should be washed with whale oil soap. But it is to the natural insect parasite when reared and set loose in the orchard that we are to look for the means of restraining within proper limits this insect. This is the minute ichneumon fly (Aphelinus) figured on page 42.

The majority of the insects injurious to the apple are found

FEEDING ON THE LEAVES.

The American Tent Caterpillar, or *Clisiocampa Americana*, is known to every farmer's boy from the social habits of the caterpillar, which lives protected from the hot sun or inclemency of the weather under a broad tent of white silk. Not very creditably to orchardists and farmers they are a conspicuous object at the beginning of summer, whether in the New England, Western or Middle states. The caterpillar is easily recognized by its large size, being about two inches in length, and by the long brown hairs and bright colors of the body, which is yellow with numerous fine crinkled black lines, forming low down on the sides of the body a black band, with a blue spot on the side of each ring. Along the middle of the back is a conspicuous white stripe. It becomes fully grown by the first or middle of June, the period varying with its geographical position. When about to make its cocoon it stops eating, and wanders restlessly about in search of a suitable place in which to spin. Under

a board or overhanging piece of bark or in any nook or cranny it settles and spins, in the course of a day or two, a dense white cocoon, often of a yellowish color, which is much like that of the common Chinese silk worm, except that it is more pointed at the ends. Our tent caterpillar is not a remote ally of the silk worm, belonging to the same natural family. The supply of silk is by no means exhausted after it spins its cocoon, for if it be removed from its silky house, after a few hours it surrounds itself by a fresh one, and even attempts a third if compelled to by the curiosity of the experimenter. It remains in its cocoon through the remainder of the month, the moth appearing early in July, when it enters our rooms with a headlong flight, and dashes in a peculiar, confused manner upon the table. The moth is unusually thick-bodied and hairy. It is reddish-brown, with two oblique, dirty white lines on the fore wings, and expands about an inch and a quarter.

The female immediately lays her eggs in a mass of three or four hundred, standing up side by side around a twig and covered by a gummy secretion. These bunches of eggs form conspicuous objects, and it is easy to pick them off after the leaves have fallen. Before the winter opens the embryo caterpillars are formed and lie in the egg shell all ready to hatch. In the spring they hatch out just as the leaves are beginning to unfold; and it is curious to watch the habits of the young caterpillars as they gather in colonies and gradually spin a silken tent in a fork of the branch. They lay down silken paths in every direction over the branches, over which they travel back and forth, their journeys becoming longer as the leaves disappear before their ravenous jaws. They work in the forenoon and afternoon in pleasant days, taking a siesta at noon, or in stormy weather huddle up together upon or under their silken canopy. This caterpillar, so large and conspicuous, is easily dealt with, as the nests can be easily removed by a brush or mop dipped

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in strong soap suds or a weak solution of coal oil or carbolic acid.

The original home of this moth is the wild cherry. Another closely allied species sometimes found on the apple, for which it deserts its favorite food-tree, the oak, is the Forest tent caterpillar. It differs from the other species in having a row of spots along the back instead of a continuous line. The moth differs in the wings being more pointed at the apex, and in the transverse lines being rust brown.

Not only do certain carnivorous beetles and a parasitic fly (Tachina) prey upon the caterpillar, but we have also found a small chalcid fly lurking under the mass of eggs, in which it was undoubtedly parasitic.

The Canker Worm.—The traveller through eastern Massachusetts, particularly in the neighborhood of Boston, is often struck during the early weeks of June by the desolate appearance of the orchards, which look as if a fire had passed through them. There is not a green thing on the trees, but all the branches are hung with a multitude of skeletonized leaves, rusty, sere, and fluttering feebly in the breeze. This is not the work of fire, but an evidence of the industry of the canker worm. This scene has been repeated ever since the apple has been raised, or at least for a century, and is liable to be repeated for a hundred years to come, unless a law is enacted to compel negligent farmers and gardeners to properly protect their trees. When the buds of the apple leaves are opening we shall on careful examination find a few little dark worms scarcely thicker than a horsehair, nibbling the exposed edges of the opening leaves. Before people are aware of it these tiny caterpillars become nearly an inch long, and defoliate the tree. One can stand near the tree and hear the nibbling of thousands of little teeth. No one attempts to arrest the progress of the destroyers, and their advent is looked upon with dismay, mingled, however, with a large proportion of fatalism. No one

seems to attempt to remove them. The loss of the leaves does not kill the trees, but prevents the growth of any apples. When these canker worms are fully grown, *i.e.*, about four or five weeks after they are hatched, between the 17th and 27th of June about Boston, they will be found to vary exceedingly in color, some individuals being blackish, others greenish-yellow. The average style of coloration is an ash color on the back, beneath yellowish, with a black stripe on the sides. It has a less number of feet than most caterpillars, which gives it a halting, looping gait, as if carefully measuring the ground over which it is walking; hence the name geometer. Deserting its tree top it either creeps down the trunk of the tree, or lets itself down after the manner of most caterpillars by means of a silken thread spun from a little opening in its under lip. It doesn't wander about, but immediately burrows from two to six inches in the loose soil under the tree, and then forms a rude loose earthen cocoon, fastening the particles of dirt together with silk. Twenty-four hours after the cocoon is finished the worm changes to a chrysalis, which is rather pointed in front and light brown in color. Here the insect remains until after the October frosts, when on warm days between the cold snaps late in October, and in November and December, and even in some exceptionally warm days during the rest of the winter, the adult insects come forth.

Nature has endowed the sexes quite differently; the male is winged and flies about in a modest Quaker garb of gray, fluttering with broad weak wings about the trunks of the trees and paying court to the grub-like wingless females, which are less flighty than their mates. A larger proportion of individuals appear in the spring than winter. This provision of nature that a part of the brood shall appear in the autumn and a part in the spring ensures the life of the species, since if it were not represented in part by the eggs and chrysalides, a severe winter might destroy the latter,

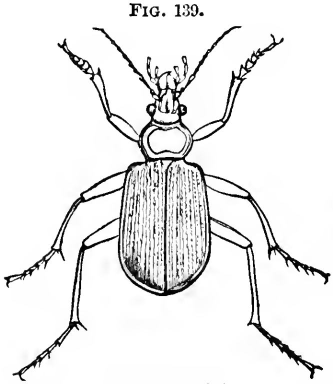
and cut off the brood. The eggs have so thick a shell that it seems impossible that even great extremes of temperature should destroy them. They are laid in broad patches of from sixty to a hundred or more, standing up side by side. They are glued together and to the bark or paling by a grayish varnish, secreted by a gland in the end of the body.

In dealing with this caterpillar the obvious preventive measure is to keep the females from ascending the trunks of the trees and laying their eggs on the branches. This is done in a cheap and efficacious way by surrounding the trunk of the tree with a band of tarred paper and anointing it with printer's ink. If the ink is daily applied this is a cheap and sure preventive. Another one, involving more expense but less time and trouble, is to surround the base of the trunk with a wooden trough kept filled with oil or ink; or it may be raised and made of zinc, and filled with whale oil. But all these methods are useless unless the shiftless and careless are compelled to coöperate with those who take pains to keep their trees free from the caterpillars. We have ventured to suggest, in our first "Report on the Injurious and Beneficial Insects of Massachusetts," that it is only by combination between farmers and orchardists that these and other pests can be kept under. As we then said, "The matter can be best reached by legislation; we have fish and game laws, why should we not frame a law providing that farmers, and all those owning a garden or orchard, should coöperate in taking preventive measures against injurious insects, such as early or late planting of cereals to avert the attacks of the Wheat midge and Hessian fly, the burning of stubble in the autumn and spring to destroy the joint worm, the combined use of proper remedies against the canker worm, the various cut worms, and other noxious caterpillars. A law carried out by a proper state entomological constabulary, if it may be so designated, could com-

pel the idle and shiftless to clear their farms and gardens of noxious animals." We trust that those interested will not suffer this matter to drop, but that a law correcting this abuse of privilege in letting these destructive insects run riot may be framed and passed.

Among the natural enemies of the canker worm is the *Calosoma scrutator* (Fig. 139), a beautiful ground beetle which ascends the trunks of the trees and devours the caterpillars. Certain wasps, particularly the Eumenes, store up the caterpillars in their nests. The Tachina fly, and an ichneumon fly, are also said to prey on them, while hogs and fowl devour the chrysalides. Next to the parasitic ichneumons, however, the smaller birds are the most efficacious in destroying them. I extract as follows from a paper in the "American Naturalist" (May, 1874) important testimony on this point:—

FIG. 139.



Calosoma scrutator.

"I am indebted to Mr. C. J. Maynard of Ipswich for the following information upon the birds which devour the canker worm. He informs me that in the course of his investigations he has opened the stomachs of some three thousand birds.

'In answer to your questions relative to birds eating canker worms and the larvæ of other injurious insects I would say that upon examining my notes, I find that I have taken canker worms from the stomachs of the following species:—red-eyed vireo (*Vireo olivaceus*), song sparrow (*Melospiza melodia*), chickadee (*Parus atricapillus*), scarlet tanager (*Pyranga rubra*), robin (*Turdus migratorius*), black billed cuckoo (*Coccygus erythrophthalmus*), wood pewee (*Contopus*

vireus), least pewee (*Empidonax minimus*), Wilson's thrush (*Turdus fuscescens*), black and white creeper (*Mniotilta varia*), blue yellow-backed warbler (*Parula Americana*), Maryland yellow-throat (*Geothlypis trichas*), Nashville warbler (*Helminthophaga ruficapilla*), golden-crowned thrush (*Seiurus aurocapillus*), chestnut-sided warbler (*Dendroica Pensylvanica*), yellow warbler (*D. æstiva*), black and yellow warbler (*D. maculosa*), prairie warbler (*D. discolor*), black-polled warbler (*D. striata*), Canada warbler (*Myiodioctes Canadensis*), redstart (*Setophaga ruticilla*), cedar bird (*Ampelis cedrorum*), cat bird (*Mimus Carolinensis*), purple finch (*Carpodacus purpureus*), white winged crossbill (*Curvirostra leucoptera*), chipping sparrow (*Spizella socialis*), indigo bird (*Cyanospiza cyanea*), red-winged blackbird (*Agelaius phœniceus*), cow blackbird (*Molothrus pecoris*), bob-o-link (*Dolichonyx oryzivorus*), Baltimore oriole (*Icterus Baltimore*).

'Possibly this list may be increased. Besides these birds, those species which occur in orchards during autumn and winter, such as the ruby crowned wren, brown creeper, nuthatches and titmice, doubtless eat largely of the eggs of canker worms and other insects which destroy or injure the trees. Winter birds of the above species which I have shot at this time have their stomachs crammed with insects of some kind.

'As I remarked to you the other evening, the Baltimore oriole will eat largely of the tent caterpillar, and is the only bird which will do this.

'All the thrushes will eat wire worms. The swallows destroy multitudes of dipterous insects (gnats, etc.). In fact, to sum the matter up there is scarcely a bird which will not eat largely of insects at certain seasons, when these pests are most abundant.

'It is a noticeable fact that many species inhabiting woods and meadows, as may be seen by the list given, leave their

usual haunts and visit the fruit trees which are covered with canker worms and largely devour them.

'In reference to the currant saw fly worm (*Nematus ventricosus*) I am not certain that I have seen any birds eat them, yet I think the truly insectivorous species will do this.'

"That the Baltimore oriole sometimes eats large quantities of the American tent caterpillar (*Clisiocampa Americana*), since they have been found in the stomach of this bird by Mr. Maynard, is an interesting fact, for birds as a rule do not relish hairy caterpillars, and the American tent caterpillar is covered with long hairs, though they are not so dense as in some other larvæ. In Europe the closely allied tent caterpillar (*C. neustria*), and those of the *Cnethocampa* and *Liparis chrysorrhœa* are said by Perris and others to be almost untouched by birds. I have been told by Dr. T. M. Brewer of Boston that the English sparrows upon the common devoured all the caterpillars of the tussock moth (*Orgyia*) which were injuring a fine tree. These caterpillars are very hairy, being adorned with pencils and tufts of long hairs.

"Mr. John H. Sears, of Danvers, Mass., who has paid much attention to the habits of our birds, informs me that the cuckoo, which breeds near houses, is an exceedingly useful bird, as it devours the canker worms in large numbers. It is well that this should be known, as there is a popular prejudice against this bird, from its habit of sucking the eggs, as well as laying its eggs in the nests, of other birds. Among the birds which he has himself observed in the act of eating canker worms, are the king bird, the Baltimore oriole, the cat bird, the common flycatcher, the least flycatcher or wood pewee, the red eyed vireo and a few other small birds, such as certain warblers and flycatchers. The king bird in the month of May feeds on May beetles, as stated by Mr. J. L. Hersey, in this journal.

"I also quote from a letter on the subject, for which I am indebted to Dr. T. M. Brewer:—

'The most noticeable of all the destroyers of the canker worm is the common cedar bird, which devours them to an extent perfectly enormous. Next is the purple grakle which also feeds on them as long as they last. The house pigeon, if in any numbers, is an invaluable bird. See, for instance, a garden corner of Summer and Chestnut streets, Salem, where the pigeons make canker worms a thing unknown. Among the other birds, all excellent so far as they go, are the chipping sparrow, the song sparrow, the purple finch, all the vireos, white-eyed, red-eyed, yellow-throated, solitary and warbling, the king bird, the cat bird, the downy woodpecker, the summer yellow bird, Maryland yellow throat, the blue-bird. The bluejay eats their eggs in the winter, so does the chickadee. The latter eats their grub also and the worm too. The common gray creeper, which is with us only in the winter, eats the eggs.

'Last summer I had a nest of golden-winged woodpeckers breeding on my place at Hingham. Some of them dug into my barn and passed the winter. Only a part of my trees were protected by a belt of printers' ink and some of them were partially eaten, but this winter very few grubs have as yet shown themselves, and I give my friend, *Colaptes auratus*, the credit of all this. I know this—I gave the young ones a lot of worms myself and they ate them as if they were used to them. The old birds were too shy to permit me to see their good deeds.

'I think the golden robin feeds its young with them as long as they last, but I am not sure that they eat the tent caterpillar. I nearly forgot the two cuckoos, yellow-bill and black-bill. They eat every form of caterpillar, canker worms included. I do not think the robin feeds any to its young, because it would never do; they are too small, and its brood want a big lot. I have known the robin to feed its young

for entire days, as fast as they could bring them, with the moth of the cut-worm. That is about as much as we could expect any bird to do at one time. At the rate they went, they must have caught and given their young ones about five hundred of these moths in a day. Before that, I had supposed that the robin did me more harm than good, but I had to give in. My indebtedness to that pair was worth all the cherries I could raise in many years. So the robin and I are fast friends.'"

From the facts already presented, it may be inferred how useful birds may become in the work of reducing the number of injurious insects. Undoubtedly we have suffered greatly by our wanton killing of the smaller birds. We are far behind European nations in caring for the insect-eating kinds, and providing nests for them about our houses and gardens. The Swiss and French have been the most far-sighted in this matter of the protection of the smaller insectivorous species. The English, Scandinavians and Germans foster them, while in our country, teeming as it is with hosts of ravaging insects, the smaller birds are hunted and persecuted, or if let alone, there is no effort made on any extended scale to invite them to our houses and gardens.

The Apple Sphinx.—This modest gray hawk moth, rather smaller than the generality of the species, appears in June and lays scattered eggs on the leaves, from which the caterpillars hatch. They are large, pea-green worms, with seven oblique violet stripes along each side, and a horn on the end of the body. It is the *Sphinx gordius.* The larva of another hawk moth, with a rough granular skin, a bluish horn and seven yellowish white streaks on the side, is also found on the apple. The moth is fawn colored, with the wings notched, the hinder pair bearing a large black eye-spot centred with blue. It is the *Smerinthus excæcatus.*

The Swallow Tail Butterfly.—The caterpillar of *Papilio Turnus* is occasionally found on the leaves of the apple. It

is a smooth, fat, green worm, with two eye-like spots behind the head. It changes to a chrysalis in August. These three caterpillars do little or no harm to the tree, and are only mentioned on account of their large size and curious appearance.

The Apple Nola.—We have not ourselves identified the caterpillar of this well known moth. It is said by Dr. Fitch to be a rather thick, cylindrical, light green worm, an inch long, with five white lines and numerous white dots, and was observed eating notches and holes in the leaves. It changes to a cocoon in a curved leaf. The moth appears in July, and also hibernates, flying about in spring. It is gray, crossed by three zigzag black lines. It is the *Nola malana.*

The Bud Worm.—One of the most injurious insects of the apple tree, next to the canker worm, that we have, is a small, reddish-brown larva, which, during certain years, threatens, in some localities, the extinction of our apple crop. It was described by Harris, in his "Treatise on the Insects injurious to Vegetation," under the name of *Penthina oculana*, and should now be named *Grapholitha oculana.* The caterpillar is a small, cylindrical, naked worm, about a third of an inch in length, and of a uniform reddish-brown, with small warts, from which arise short, fine hairs, while the head and upper side of the prothoracic ring, or segment next the head, is black.

On May 16th I noticed this caterpillar on the apple, and also the pear and cherry, perforating the half expanded leaf and flower buds. They were very abundant on these buds, and afterwards, when the leaves had partially expanded, they had folded them. It seems to hatch out about the time that the canker worms and American tent caterpillars leave their eggs, that is, about the first day of May, when the buds unfold. The last of May and the first week of June they were swarming in orchards throughout eastern

Massachusetts, many persons noticing their attacks; and it seems to be a common insect all over New England. When fully grown it crumples the leaves, disfiguring the whole tree, and doing great damage to the fruit-buds and flowers, thus directly lessening the apple and pear crop. About the first of June they cease eating, and make a loose, delicate silken cocoon in the folded leaf. They remain several days —sometimes nearly two weeks—in this condition before assuming the chrysalis state, about the 16th of June, and the moths are seen flying about and entering houses, attracted by the light within, during the last week of June and the first of July. The chrysalis is brown and of the usual shape, and, as Harris states, has but a single row of teeth along the dorsal side of each abdominal segment. After the moth has slipped out of the pupa case, the empty shell remains attached by the tip of the abdomen to the surface of the leaf.

The moth is of a dark ash color, the fore wings being usually paler in the middle. The basal third of the wing is dark ash mottled with paler scales, the outer edge of the dark area being angulated just behind the middle of the wing. The costa is marked with light and dark bands. On the outer third the wing is nearly as dark as on the base; near the outer edge, and half-way between the costa and hind edge, are four well-marked longitudinal black spots, or short lines running parallel with the costa, or front edge, of the wing; the one nearest the costa is simply an elongated dot, the second and largest is an oblong spot and twice as wide as the third spot, while the fourth again is much smaller. There are three similar black marks situated on the inner edge at the outer third of the wing. When the wings are folded over the back, these black marks, collectively, make a rudely triangular figure. The outer third of the wing is also variously banded and mottled with leaden blue and tawny brown scales. The fringe is brown and

leaden blue. The hind wings are dark ash brown. Beneath, the fore wings are not mottled, but uniformly dark ash brown, and a shade lighter than the upper surface of the hind wings. It expands about ·55 of an inch.

It varies in the distribution of the black spots, and in the degree of angularity of the outer edge of the basal dark portion of the fore wings; and in some specimens the middle of the wing is concolorous with the other parts, and the peculiar leaden blue scales are scattered over the whole wing, with a black patch on the inner third of the wing near the inner edge. In some specimens there are more than four dots near the outer edge of the wing, forming a transverse row.

As these worms attack the fruit and leaf-buds, it is difficult to pick them off by the hand without injuring the buds; nor is it easy to apply whale-oil soap or a weak solution of carbolic acid. Both of these remedies, however, should be tried, especially showering the terminal branches of the tree with soap suds or a very weak solution of carbolic acid. A faithful application, for one season, of these and other remedies, will materially lessen the numbers of this formidable pest.

The Palmer Worm.—During the latter part of June, as observed on the Hudson River, the leaves of the apple become badly worm-eaten, with the remnants carelessly sewn together with fine silken threads. When the bunch of leaves is disturbed, out scrambles a pale yellowish green caterpillar, with a dusky stripe along each side, edged above with a narrow white stripe, and drops a few inches, hanging suspended by a thread. This is the Palmer worm described under the name of *Chætochilus pometellus* (Harris).

This insect has not been of late years at all common in our orchards. We have had no personal acquaintance with it, and the following account of it is condensed from Fitch's admirable description. There are insect years as well as

apple years. Seasons when through favoring causes certain species appear in extraordinary numbers. The causes would not seem to be wholly climatic, for during seasons that may seem to be peculiarly favorable to insect life, every species does not abound in equal numbers. It seems more probable that the increase in a species is owing to a decrease in the numbers of the ichneumons attacking it, though the causes leading to the partial extinction of the ichneumon may be unknown. How full of interest would be a study of such phenomena as the periodical or unusual abundance of certain animals! No subject could be more attractive to the biologist, while none is of more practical importance to the gardener or farmer; and it is just such studies as these that our young students should take up.

"In the year 1791," says Fitch, "the orchards and forests of New England were overrun by this worm, and the leaves of the apple, oak and other trees were devoured by it. It was at this time that it received the name 'Palmer worm,' by which it has since been currently designated. This name was evidently derived from our English translation of the sacred scriptures. Another insect, which a month or two before had devastated the fruit trees to an extent never previously known, appears simultaneously to have received the name which it still retains, the canker worm; for previously to this date we find this name given to what is now called the army worm." (*Leucania unipunctata.*) "Another remarkable visitation of these insects occurred in the year 1853, unparalleled by any event of this kind within the memory of the present generation." It appeared "suddenly in excessive numbers" from Maine to eastern New York. The Palmer worm appears about the middle of June, about the time the canker worm is entering the earth, and continues till the close of the month. It strips off the foliage, thus emulating the gastronomical feats of the canker worm. Dr. Fitch says that should, "after a visitation from these worms,

the weather during the month of July prove to be dry and hot, as it frequently is, the damage is much more extensive, whole orchards and forests perishing." In 1853 the worms "continued in full force until the night of the 23d of June, when brisk showers occurred, accompanied with heavy thunder, terminating the drouth which had prevailed, and with this the worms suddenly disappeared." In one orchard a thousand bushels of apples were destroyed, that being the usual yield. "When they are young these worms eat only the green pulpy tissues of the leaf, leaving its net-work of veins entire. But as they become larger and more robust they consume the whole of the leaf, except the coarse veins. It is the young and tender leaves, however, which grow at or near the tips of the limbs, which they prefer; the older and tougher leaves are commonly eaten only at their tip ends, and have irregular holes of various sizes gnawed in them, some of these holes being no larger than a puncture made with a pin. The green succulent ends of the twigs are also frequently eaten off. And the young apples, which were nearly as large as walnuts when these worms made their appearance, almost without exception had either round holes or larger irregular cavities gnawed in their surface. Thus wounded they wilt and fall from the tree, a few only having the wounds so slight that they recover and remain upon the tree until they ripen."

The moth into which the Palmer worm transforms closely resembles the Gelechia of the granaries. It is of an ash gray color, with six or seven equidistant black dots at the base of the fringe on the outer edge of the wing. In the middle of the wing are four larger dark dots, which are placed obliquely with regard to each other; the wings expand between a half and three-quarters of an inch. It belongs to the family of Tineids, which have small, narrow wings, with long, silky fringes. The common clothes moth is a type of the family. Fitch recommends showering the

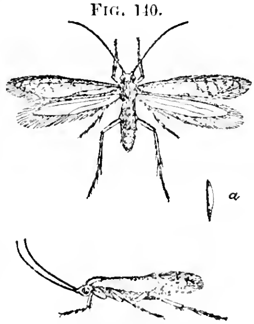
trees with whale-oil soap diluted with water. Frequent drenchings, natural as well as artificial, are extremely useful in ridding trees of caterpillars, and turning the hose on infested trees is an excellent remedy against all sorts of caterpillars, particularly the bud worm and Palmer worm.

The Twin Spotted Leaf Miner.—Another of that exquisite family, the Tineids, often infests the apple in immense numbers, mining the leaves, leaving a serpentine blotch to mark the site of its gallery. It bears the sesquipedalian name of *Lithocolletis geminatella.* It is figured in all its stages on plate 8 of the "Guide to the Study of Insects." The little caterpillar is slightly over a line in length (·14 inch), of a pale livid reddish hue with a black head, the segment behind the head being also blackish. When it becomes fully fed it transforms into a chrysalis within its mine. When disturbed it crawls rapidly out of its domicile and hangs suspended by a thread, unwittingly open to the attacks of the smaller birds, to whom all these minute leaf-rolling and mining caterpillars are a dainty tit bit. Indeed, were it not for the kind offices of these feathered friends of ours, these tiny thieves would leave no food for their giant friends, the canker worms and tent caterpillars. The worms occur throughout the last of summer and early autumn, while the moths first appeared in Salem on the 19th of August, flying in doors during the night, attracted by the light. It is a beautiful creature, with long, narrow, delicate wings fringed with long lashes, with a yellowish tuft of hairs on the top of the head. It is of a dark slate gray color, with an eye-like spot at the end of the fore wings, pupilled with black, like the "eye" in a peacock's tail.

The Apple Bucculatrix.— Closely resembling in its general appearance the preceding moth, this beautiful form is much paler, almost whitish, with yellowish scales, and a curved black line curving around to the apex of the wing, ending in an eye-like spot on the outer edge; in the middle of the

wing is a black oval spot. The caterpillar I have not detected. It is described, however, by Dr. Clemens as being dark yellowish green, tinged with reddish in front, with a brown head. It was found feeding externally on the leaves, late in September. Early in October it changes to a chrysalis within a long white cocoon, slenderer, but about as long as a grain of rice; it is tough and thick, and ribbed externally. It is a common object, found attached to the bark of the tree in May as well as the autumn and winter. These little moths are not exempt from parasitic ichneumons of exceeding minuteness, which send them to an early grave. Indeed the mortality among moths is greatest during their childhood, when they are in the chrysalis state. While a few caterpillars, like very many human children, die of over-eating, the greater number of deaths are due to causes beyond the control of the caterpillar. In Europe, twelve hundred species of minute, chalcid ichneumon flies are known to exist, and of these many prey on the Tineids. I have found a most singular form preying on the Bucculatrix of the cedar (*B. thuiella*, Fig. 140, enlarged; *a*, cocoon, natural size), which closely resembles the apple moth. In endeavoring to rear the moth from the cocoon I found that nearly half of the cocoons gathered from a cedar tree in my yard, failed to give out their appropriate tenant, but instead, rendered account in the form of minute beautifully brilliant green flies, with golden metallic tints. The antennæ branched out like the antlers of a reindeer, each having at the end five branches, somewhat resembling a Japanese comb. These little flies are worth far more than their weight in gold, and were their worth duly appreciated our gardeners would look upon the

FIG. 140.



Bucculatrix thuiella.

cultivation of ichneumon flies as the "right arm of the service" in an enlightened agriculture.

The Apple Micropteryx.—The most abundant leaf miner of the apple, so busy a laborer that for several years past nearly every other leaf on the apple trees in my garden witnesses their plodding, patient work, is the *Micropteryx pomivorella*—nearly all these minute slender-winged moths have monstrously long names.

The caterpillar is a minute, dark, pea-green, flat worm, the body thickest in the middle and very soft. It is about a line in length. It eats its way in the interior of the leaf, between the upper and the under side, feeding on the soft pulp. Its burrow is marked by a broad waved dark line on the leaf, which widens at the farther end, and is somewhat puffed out, owing to the presence of the fully fed caterpillar. In this little terminal chamber the worm rests, and when anxious to leave it in order to spin its cocoon effects its escape through a slit, which it has had the instinct or common sense previously to cut with its jaws. So abundant is it, that multitudes of these little green worms may be seen hanging helplessly from the leaves of the tree. Suspended by this thread they swing to and fro, until they strike some twig, whence they go to the bark of the trunk and larger branches. Here in warm days late in September and early in October, the worms spin a peculiar flattened, round, silken, yellow cocoon, about a line in diameter. In confinement I have noticed that it will spin its cocoon on the leaves, but in nature it is careful to deposit them on the branches, where it remains through the winter. The larva completes the cocoon, at least all that is visible, within the space of one hour. The moth was found in considerable abundance resting on the under side of apple-leaves the 19th of June.

The body and wings are of an uniform dark bronze hue, with purple and metallic reflections; the fringe is concolo-

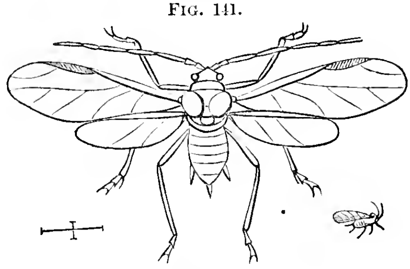
rous with the wings. On the top of the head is a conspicuous bushy tuft of bright reddish orange hairs. The legs are of a leaden hue, the hairs yellowish, the hind shanks long and hairy, with four long, slender spurs; the antennæ are dark on the terminal three-fourths, pale orange at base. The under side of the wings are leaden gray. The length of the body is ·07, and of the body including the folded wings, one-tenth of an inch.

The Sac Bearer.—Another winged gem, with a still more curious childhood than the Micropteryx, is a sac bearer, as the Germans call it. Like a boy in a meal sack, with his arms sprawling about and pulling himself along, the little caterpillar pokes its head out of its case, extends its six fore legs, like so many hands, and pulls itself over the leaf, its little world. The worm is flattened, green, and no thicker than a small knitting needle. The case or sac is oval, open at each end, much flattened and roomy enough for its inhabitant to turn around in. How the case is constructed we have been unable to observe. While some sac bearers cut an oblong slit in the leaf, fold it over, and then cutting a corresponding slit remove the folded portion, fasten together with silk the open side, wriggle into this straight jacket, and walk off as if they had been born with their houses on their backs; others probably construct their cases out of fine bits of leaf stuck together with the silken glue secreted from the glands emptying into their mouths. The material of such cases resembles a thick, felt-like cloth, and that of our sac bearer is of this nature. By the end of August the caterpillar becomes mature and ready to transform into a chrysalis. It does not desert its old coat, but hangs it by a few threads to the bark of the tree and contracts its body, lies quiet through the winter, until early in summer the chrysalis breaks through a rent in its skin and soon after the moth appears. It is now one of the most beautiful objects in nature. It is very small, the head finely dusted, its softly

fringed wings expanding only a fifth of an inch. Its fore wings are of a light slate gray color on their inner half, and beyond bright orange, enclosing two white bands, one situated on the front edge, and the other arising from the inner edge, both nearly meeting in the middle of the wing, and edged externally with black. There is a very conspicuous square black spot near the fringe, in which is a long pencil of black hairs. Such startling contrasts of yellow and black are seldom worn by these diminutive moths, but nature never outrages our notions of good taste, and these colors are blended in an harmonious and attractive way. It is doubtful whether these little sac bearers ever do any mischief to the trees, and they are more interesting than injurious. The moth, caterpillar and case are figured on the frontispiece of the "Guide to the Study of Insects."

The Apple Aphis (Fig. 141, natural size and enlarged).—The prick of a plant louse and loss of a drop or two of sap

FIG. 141.



The Apple Aphis.

is of little moment to an apple tree; so is the loss of a drop of water to a pond. But multiply the number of lost drops and the pond may dry up and the tree wither and die. The vast numbers of Aphides, often seen clustering two to three deep on the green shoots of a favorite tree in the orchard, is a lamentable spectacle. The work to be done by these insects is such as, unfortunately for the gardener, to require vast numbers. Every gap opened in their ranks, by the as-

saults of the myriad birds and insects which prey upon them, must be closed by accessions from the youth of the colony. How fertile the mothers are in means to supply this want, and with what startling precocity the new-born Aphis steps into the shoes of his sire, or more commonly his mother, we have already seen. Given a colony of, say, 1,000,000 plant lice on a choice tree, the problem before us, and it is one nature daily presents, is to reduce the 1,000,000 to 0.

Before using the various artificial remedies, excellent when faithfully applied, the intelligent gardener will avail himself of the aid of the natural enemies of the Aphis, such as the maggot of the Syrphus fly, and the larva of the lace-winged fly. If he gather these and turn them loose among the flocks of Aphides his withered trees will soon become green and exuberant.

Dr. Fitch says that the eggs are small, oval, shining, black, and placed by the parent in autumn deep in the cracks and crevices in the bark of the tree. Now, as he suggests, the practical way to deal with these pests is to scrape off the dead bark of the old trees and whitewash all the trees early in November, or very early in the spring before the buds begin to open, for at this period the young Aphides hatch, as they may be found clustered round the buds, and as soon as the green leaves begin to show themselves the Aphides puncture them. This Aphis is a European importation. The head and thorax are black, the hind body green. Among the remedies which may be applied are washes of sal soda, strong soap suds, tobacco in solution or its smoke, though this latter means is difficult to apply to any except choice small trees.

Not content with the destruction to root, trunk and leaf, a few insects devote their energies to

INJURING THE FRUIT.

The Coddling Moth.—Many a housekeeper looks with unconcern upon this little creature, quite ignorant of the mis-

chief it has done in the orchard, and that it is the cause of the wormy apples in the cellar. So with the average farmer or gardener. He little suspects that the apples falling in a still night from his trees are loosened from their twig by the young of the innocent looking moth which may be seen flying about the house, when the apple trees are in blossom, and again in the middle of August, when the apples are half formed. Many may recall the appearance of the repulsive little whitish caterpillar or "worm," occurring in wormy apples, who are not at all acquainted with the moth. It is rather smaller than the apple leaf roller, with narrower wings, and grayish ash-colored. Across the wings pass slightly marked numerous darker transverse lines, with a prominent curved black line, edged with a coppery tint, near an eye-like patch on the inner angle. The wings expand over half an inch. She lays her eggs in the calyx of the blossoms of the apple, just as the petals are falling. The worm hatches in a few days, burrowing into the core. In three weeks the caterpillar becomes full-sized, the apple prematurely drops, the worm deserts it, creeps up under the bark of the tree, cocooning and in a few days after a brood of moths appear. They are the parents of the worms which may be found through the winter and early spring under the bark, housed in their cocoons.

Taking advantage of this habit of cocooning in crevices, the best plan in dealing with these insects is to wind cloths and bands of straw around the trunks. During the last half of summer and the autumn they can be removed every few days and burned, and others put in their place.

When the fruit is stored in the cellar the maggots of three kinds of flies emulate the example of the caterpillar of the coddling moth, and further despoil the orchardist, and wound the feelings of the lover of good apples.

8. Insects of the Field.

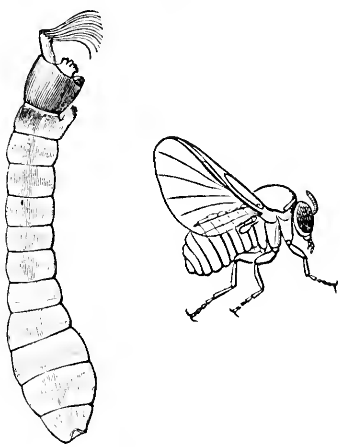
WE will now step from under the shade of the apple trees, and walk out in the open fields. And here the bustle and stir of insect life is as bewildering and overpowering to him of acute entomological sense as a walk down Broadway or along the Strand is to the rustic. Insects love the open fields. Under the shade of the forests they pursue their avocations in comparative silence; in the garden or orchard their limbs are cramped, and their gluttonous life may be accounted for in part by their sedentary habits. There they eat, drink, and sleep, and that is with them the end of their existence; but for merry making, hilarity, and a busy metropolitan industry, which shows an interest in all insect-kind, all the while intent on their own life work, and for light-hearted enjoyment of the blessings of an open sky, the breezy sod, and freedom of the grassy plains, commend us to the insects of the fields. And by fields we mean not the broad prairies or dreary moors, but the savannas and glades in forests, the lawns bordered with the hawthorn, buckthorn or cedar, and the grass lands, and wheat and corn fields.

The bees with their swift, strong, steady flight and busy hum, the grasshopper with his sprightly leap and laughing chirrup, the gorgeous butterfly floating aloft, clearing an acre in one swoop, these are the true field insects; while, envious of their active life, the noisy Cicada leaves his forest shelter and clinging to some shrub in the open field swells the chorus of insect sounds with his rattling, shrill cry.

There is really a distinct assemblage of insects peopling the fields. At the suggestion of a walk out into the open country we have visions of grasshoppers rising under our

feet in swarms, and describing, like fire works, radii of circles centring at our feet; the crickets, whose wings had been rasping their love notes, or rather, chirrups, close them tightly over their backs, and run, like so many quail, from one grassy covert to another. We always expect to find certain moths hidden in the grass of the lawn or hay field, which, startled at our approach, rise and wildly fly off in their headlong course to a fresh hiding place; and by the roadside, swarms of the yellow Colias alighting at some pool to quench their thirst. The mosquitoes we scarcely expect to find on the breezy plains. The still forest, the darker and damper the better, is their home. Favoring winds support their halting flight and bear them to our houses. On the other hand the Black fly (Fig. 142) and midge are only found on the edges of woods, in open fields and on the bare hill tops. A hundred bees may be seen in clover fields to one in the woods, the flowers attracting them rarely growing there.

FIG. 142.



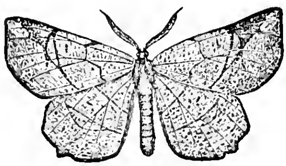
Black Fly and young, enlarged.

The Hessian fly hovers in swarms over wheat fields. The ant loves the roadside and the open glades in forests, and the wasps, when they do nest in the woods, prefer places where the scattered trees seem endeavoring to break away from the restraints of the woodland.

The insects of the field come and go with the changes of the season. Troops of moths fly about in the grass lands in May, and desert the fields during June and July, until August ushers in fresh hordes, whose highly colored, brightly

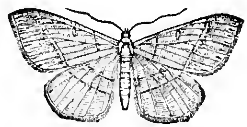
marked wings prove their recent exclusion from the chrysalis. The months of May and June are signalized by the appearance in great force of the geometrid moths (Figs. 143, 144*). They disappear from the fields in July, when swarms of owlet moths (Fig. 145) take their places, and in August others, such as the Agrotis (Fig. 146) and Plusia

FIG. 143.



Endropia.

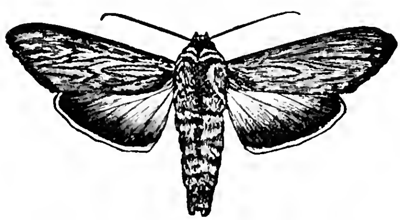
FIG. 144.



Phasiane.

(Fig. 147), which, as the name of the latter indicates, is rich in the possession of gold and silver spots on its wings; visit in the bright sunshine the flowers of the golden rod and the aster, busily engaged in collecting pollen, and unconscious agents in fertilizing the flowers of these showy plants, which do little harm, but in early autumn impart a gay, rich color

FIG. 145.



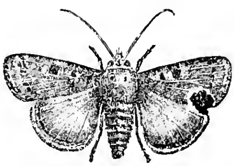
Owlet Moth (Cucullia), after Lintner.

to our sombre fields; and thus in more ways than one these insects of the field cheer up the melancholy days of autumn. The generation of moths is maintained late in September by the delicate Chain moth (Fig. 148, *Zerene catenaria* and larva) which flutters over the golden rods and sweet fern;

* From Hayden's Report on the Geology, etc., of the U. S. Territories.

while later still in warm days in November and sometimes every winter month, and in early, preternaturally warm spring days, the male canker worm flutters helplessly about our orchards and fences. The tiger beetles (Cicindela; Fig. 149, *C. sex-guttata*) are essentially field insects, loving the sandy banks of streams, the roadside and sunny paths; and the different months of spring and summer witness the arrival of different species.

FIG. 146.



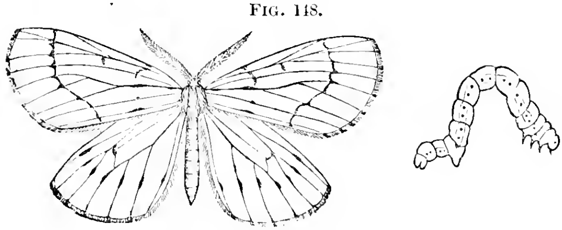
Agrotis.

FIG. 147.

Plusia.

When a tree is separated from its fellows and left standing in a field, it becomes the centre of attack of many different varieties of insects. If an oak its twigs are hung with countless galls, the flies assembling year after year stinging the leaves and branches as surely as the season comes around. The same kind of caterpillars annually receive their tribute of leaves, and the

FIG. 148.

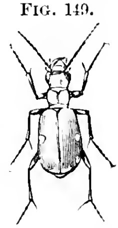


Chain moth and caterpillar.

symmetry of the oak is maintained by the judicious pruning of boring beetles and other insects, while its boughs afford rest and shelter to the birds, which in their turn judiciously check the too great increase of the insect plunderers, and instal a reign of conservative agencies which maintain the oak in its pristine vigor and hands it down from generation to generation of landed proprietors. The growth and maintenance of field crops are almost wholly regulated by the

insects, now that the birds are not allowed a fair chance of restraining the undue increase of these pests. Our potato crops are becoming dependent on the number of insects rather than the excellence of artificial fertilizers; we may top-dress our wheat fields, and till the soil never so sedulously, but the fact is well known that the wheat crop in the eastern states is nearly cut off by the Hessian fly, the wheat midge, and the joint worm. Our corn fields in the far West are dependent on the will of the grasshopper and the chinch bug. The losses annually sustained by the assaults of the armies of injurious insects are almost beyond calculation, and so quietly and neatly is the work done, that few are the farmers who realize the extent of the loss and how it has been effected. Not until they study the daily life of these insects and watch them by day and night, and know something of their life history; until they recognize the fact that as caterpillars and chrysalides and winged insects they lead different lives, have quite different means of livelihood, can they appreciate the extent of the powers for mischief in the little beings they trample on unconsciously or in contempt.

FIG. 149.

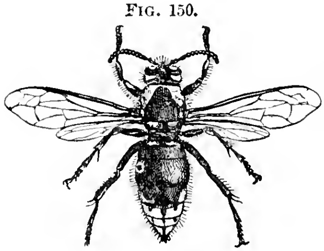


Tiger beetle.

What meaning is there in the bustle and hum of insect life, to which the ears of most of us are deaf? The only way to answer this question is to sit down for oneself and watch the daily doings of some one insect and make a record of them, by which others may profit. The busiest man can devote a few minutes each day to a study of the common insects that enter his window or visit the flowers in his garden. He can readily train the ladies of the household, or the children, to aid in the work of observation, and by thus combining the aid of several observers, test their several results. All this does not require a scientific knowledge of the anatomy and physiology of these creatures; only a little patience and interest in the subject of inquiry. An

example of what one may do whose time is occupied with multifarious duties is afforded by the results obtained by Sir John Lubbock, and published in a paper entitled "Observations on Bees and Wasps," read at a late (1874) meeting of the Linnæan Society of London. In order to ascertain how a honey bee fills out the measure of a day he kept some bees in a hive in his room, and marked some of them and watched their goings in and out. A bee between 7 A.M. and 12.52 P.M. made twenty-three visits from the hive to the honey. During an hour and twenty minutes of this time access to the honey was cut off. Another bee between 7.23 A.M. and 12.51 P.M. made nineteen visits to the honey, the door being closed for thirty minutes of the time. Still another bee, between 9.19 A.M. and 1.54 P.M., made twenty visits to the honey. Other data are given, showing the close application of these bees to their business, and that the popular notions as to their busy ways are well founded. They apparently work after noon as well as before noon. One of Lubbock's marked bees made twenty-eight visits between 12.15 P.M. and 6.14 P.M. Similar experiments made on wasps (Fig. 150, white-faced wasp) show that they emulate the busy ways of their cousins, the bees. Indeed, it is perhaps not too rash a conclusion to draw from these and observations on other insects that a ceaseless activity pervades the members of the republic of insects; and that their moments of rest only result in still greater activity.

FIG. 150.



White-faced Wasp.

Were it not for this unremitting toil in providing for the welfare of their progeny, which in bees, especially, consists in extracting honey from flowers, many species of plants would become extinct. Nay, it is safe to state that many

kinds of plants would never have been brought into existence at all had it not been through the modifying influence of bees and moths. The interdependence of insects and plants lately shown to exist by various observers is one of the most striking in nature. Many gardeners are aware that bees aid greatly in the fertilization of the flowers of the melon, cucumber and squash by conveying the pollen of one flower to another and to those of adjoining gardens. This ensures the production of fruit, where otherwise many a flower would be barren. It is known that a larger crop of apples is raised when a hive of bees is stationed in the orchard. The bees visit every flower, busily flying from one to another, and then passing to an adjoining tree. Their bodies dusted over with the pollen rub against the pistils of hundreds of flowers, which thus become fertilized. In the same manner the moths, bobbing their heads into the tubular flowers of the orchids and other plants, probe them with their long tongues, and withdraw them with a packet of pollen attached, which they leave on the pistil of some other plant. In this way the plant maintains its existence; and there is no deterioration in the stock, since the pollen is conveyed from plants afar off by the bees, and too close in-and-in breeding, a thing nature abhors, is prevented. Now this sort of work is going on far more extensively than was suspected before Mr. Darwin called the attention of naturalists to the matter. It seems, from the studies of Sprengel, Darwin, Hermann Müller, and others, that on the other hand many of the strange modifications in the form of flowers are due to insects. Not only are changes in form produced by the different kinds of insects and their varying mouth-parts, but it has been boldly suggested* that originally the scent and color and even the honey of flowers are due to the influence of insects. On the other hand any one

* "On British Wild Flowers considered in Relation to Insects." By Sir John Lubbock. Macmillan & Co. 1875.

by reading the admirably lucid statements of Müller and Lubbock can for himself realize how dependent the form of the insect, particularly the form of the mouth-parts and legs, are on the form of the flower. As Lubbock remarks, "there has thus been an interaction of insects upon flowers, and of flowers upon insects, resulting in the gradual modification of both."

The transfer of pollen from plants of different varieties or species results in hybrids which are much larger than the original forms. Cross fertilization, as this is called, is an advantage to the plant, and is resorted to constantly, as every body knows, by horticulturists. Lubbock quotes Darwin's remark that "all experimenters have been struck with the wonderful vigour, height, size, tenacity of life, precocity and hardiness of their hybrid productions." Mr. Darwin was the first to show that if a flower be fertilized by pollen from a different plant, the seedlings so produced are much stronger than if the plant be fertilized by its own pollen. Lubbock, from whom we take this statement, saw these experiments of Mr. Darwin, and remarks that the difference was most striking. "It is, moreover, remarkable that in many cases plants are themselves more fertile if supplied with pollen from a different flower, a different variety, or even, as it would appear in some instances (in the passion flower, for example), from a different species. Nay, in some cases pollen has no effect whatever unless transferred to a different flower. Fritz Müller has recorded some species in which pollen, if placed on the stigma of the same flower, has not only no more effect than so much inorganic dust, but, which is perhaps even more extraordinary, in others, he states that the pollen placed on the stigma of its own flower acted on it like a poison. This he noticed in several species; the flower faded and fell off; the pollen grains themselves and the stigma in contact with them, shrivelled up, turned brown, and decayed; while other flowers on the

8

same branch, which were not so treated, retained their freshness." Now, as we have said, the great agencies in nature in performing this act of cross fertilization are the wind and insects, principally the latter. The stamens and pistils of the pines, birches, poplars, grasses, corn and other cereals are so arranged that the wind fertilizes them, but in a large number of flowers the stamens are so situated in relation to the pistils, that the ovule in the latter can only be fertilized by the agency of insects. For this end the plant must hold out some inducement to the bees and moths, in order to attract them, something besides bright colors and sweet smells, which are known to attract insects. "Flowers, however sweet-smelling or beautiful, would not be visited by insects unless they had some inducements more substantial to offer. These advantages are the pollen and the honey; although it has been suggested that some flowers beguile insects by holding out the expectation of honey which does not really exist, just as some animals repel their enemies by resembling other species which are either dangerous or disagreeable."

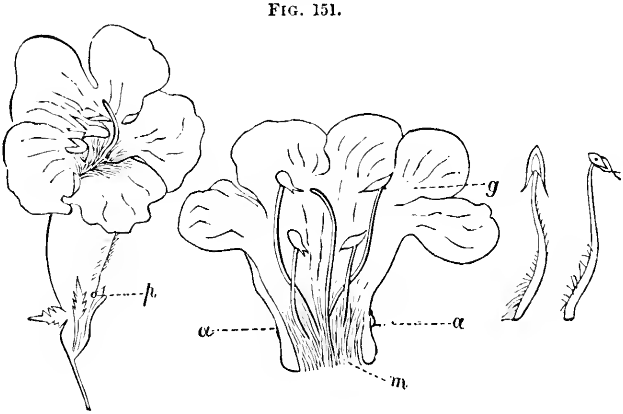
That many insects are attracted by smells we well know, but Lubbock has been the first to show that bees and wasps are attracted by and can distinguish colors. "I placed," he says, "slips of glass with honey, on paper of various colours, accustoming different bees to visit special colours, and when they had made a few visits to honey on paper of a particular colour, I found that if the papers were transposed the bees followed the colour."

The bright streaks of different hues which adorn the petals of flowers serve the most utilitarian purpose; namely, as guiding lines to show the bee the way down to the deposit of honey. At figure 151, *g* indicates the bright colored guiding lines which lead down to the nectary. Lubbock remarks that he did not realize the importance of these guiding lines until, by experiments on bees, he saw how

much time they lose if honey, which is put out for them, is moved even slightly from its usual place. With good reason, therefore, he adopts Sprengel's suggestion that the lines and bands by which so many flowers are ornamented have reference to the position of the honey. Lubbock observes that these honey guides are absent in night flowers, where of course they would not be visible, and would therefore be useless, as for instance in certain English flowers, as *Lychnis vespertina* or *Silene nutans;* it is a curious fact that the former flower is white, while *Lychnis diurna*, which flowers by day, is red.

In some cases bees, baffled in their attempts to find the honey, take a short cut and perforate the corolla with their jaws. The first and only instance yet known of this curious

FIG. 151.



Gerardia perforated by bees.

trait in this country is that given by Mr. W. W. Bailey in the "American Naturalist," 1873. He noticed that the flowers of *Gerardia pedicularia* were perforated by the bees at the point indicated by *p* in figure 151 (also seen at *a*, where the corolla is split open). Mr. Bailey writes, "I have seen bees approach the front for a moment and then retire

as if baffled. Most of them, however, begin operations at the back at once. They alight with the tail towards the open end of the flower, and at once insert the head into the little hole. I have never seen them make the aperture, although it is difficult to find a blossom without one. Even the buds are often penetrated; out of a large number of flowers plucked at random from different plants in different localities I cannot find one flower without the slit." The bees alluded to were humble bees. In Europe they are known to perforate the flowers of the bean and similar plants.

Lubbock, in concluding a chapter on the importance of insects to flowers, says that to insects "flowers are indebted for their scent and colour; nay, for their very existence, in their present form. Not only have the present shape and outlines, the brilliant colours, the sweet scent, and the honey of flowers been gradually developed through the unconscious selection exercised by insects; but the very arrangement of the colours, the circular bands and radiating lines, the form, size, and position of the petals, the relative situations of the stamens and pistil, are all arranged with reference to the visits of insects, and in such a manner as to insure the grand object which these visits are destined to effect."

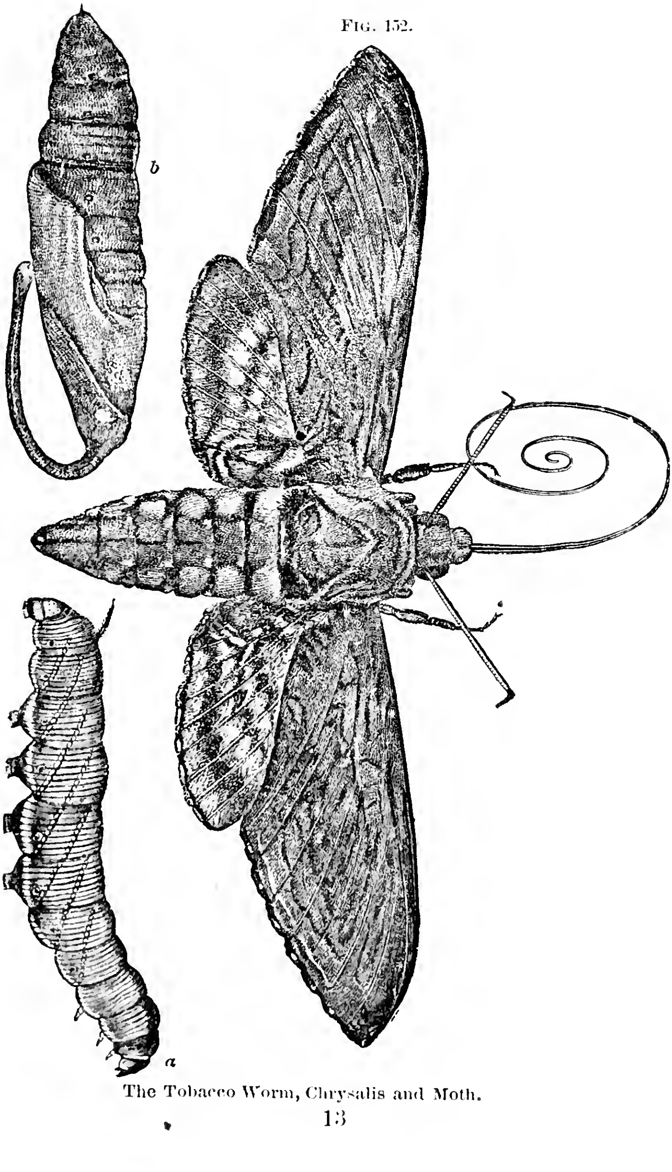
It will be seen from these facts and suggestions that the distribution of insects depends largely on that of plants. A field of clover will attract humble bees for miles around; the night flying moths are attracted long distances to those flowers which are open at dusk, at night or in the early morning, such as the honeysuckles, pinks, scarlet runners, petunias, and other tubular flowers. Indeed, Lubbock remarks in this connection that "flowers which are fertilized by night-flying insects would derive no advantage from being open by day; and on the other hand, that those which are fertilized by bees would gain nothing by being open at night. Nay, it would be a distinct disadvantage, because it would render them liable to be robbed of their honey and pollen, by in-

sects which are not capable of fertilizing them. I would venture to suggest, then, that the closing of flowers may have reference to the habits of insects, and it may be observed also in support of this that wind-fertilized flowers do not sleep; and that some of those flowers which attract insects by smell, emit their scent at particular hours; thus *Hesperis matronalis* and *Lychnis vespertina* smell in the evening, and *Orchis bifolia* is particularly sweet at night."

The tongue of the hawk moth is often of great length, adapting it for probing the deep corollas of various orchids, etc. For example, the tongue of the moth of the tobacco worm (Fig. 152; *a*, caterpillar; *b*, chrysalis with its large tongue case reaching to the middle of the body) is very long, but still moderate in its proportions compared to that of a Madagascar species in which it attains a length of nine and a quarter inches, and as there are said to be orchids with flowers as deep as this, there is evidently a relation of cause and effect between the two facts. Some moths, such as the silk worm moths, have the tongue undeveloped and they are not known to visit flowers. Other modifications in the palpi and legs of insects are correlated with the different methods insects take to collect and bear away pollen and honey.

It is a significant fact, which has been alluded to by authors, that in the arctic regions many flowers are wanting, which elsewhere are fertilized by insects also absent from circumpolar lands. If plants were introduced they would become extinct, possibly not on account of the severity of the climate, but because there would be no insects to render the flowers fertile and capable of producing seeds. The advent of many, if not nearly all the flowering plants in past geological periods undoubtedly went hand in hand with the appearance of insects. Now the bees and moths and butterflies, particularly the bees, are among the most highly developed of insects, and were the last to appear in the later geological periods. What a striking exemplification of the

FIG. 152.



The Tobacco Worm, Chrysalis and Moth.

harmonies of nature, this coeval birth of flowers and insects, each modifying the other; new forms of animals giving rise to new floral creations!

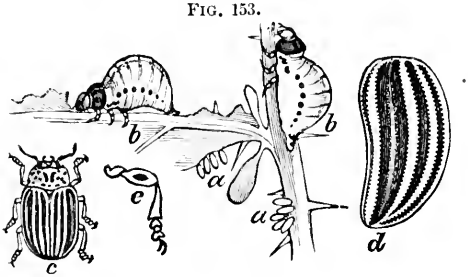
But in this utilitarian age and country it will not do to speak of field insects without mentioning those which ravage our field crops, as well as those which aid in producing them. Perhaps no insect in this country, except the cotton worm, has carried more consternation among farmers than the plump-bodied, phlegmatic, well-to-do looking beetle, which from living a quiet, harmless life on the wild, useless species of Solanum in the valleys at the base of the Rocky Mountains, has suddenly invaded our potato fields and robbed our farmers of hundreds of thousands of dollars' worth of this important crop. Not a European importation, this insect has made its home in a region of our country differing far more in its physical and climatic features from its native territory than does Europe from the northeastern states. It is an example, to use the language of the botanists, of a *prepotent* insect, which, like a weed when introduced into a new country, increases far more rapidly than at home, and crowds out the native insects, asserting itself everywhere in our farms and highways and byways.

Mr. B. D. Walsh, late state entomologist of Illinois, has given us an interesting history, in the "Practical Entomologist," of the first appearance of this insect. He shows that the original home of this beetle was in the valleys of the Rocky Mountains in Colorado Territory, where for nearly fifty years it has been known to feed upon a wild species of potato (*Solanum rostratum*). When these valleys became settled and the potato planted there, this beetle adopted it as its food, and then began a new chapter in its history. It should be remembered that the potato is also a species of Solanum, and the change in the nature of the beetle's food not great. By 1859 it had spread eastward to within a hundred miles of Omaha, Nebraska. In 1861 it

passed into Iowa, and in 1864 and 1865 it crossed the Mississippi, a thing which never ought to have been allowed. It invaded Illinois on its western border, crossing over from northeastern Missouri and Iowa. Mr. Walsh predicted that it would advance eastward at the rate of fifty miles a year. In 1868 it appeared in Ohio. Mr. Riley states that its average annual progress towards the east has been upwards of seventy miles. "At the same rate of progression it will touch the Atlantic Ocean in about ten years from now, or A. D. 1878."* But in fact it has travelled faster than that, and the year 1876 will witness the arrival of this pilgrim from the west in the potato patches of the descendants of the Pilgrim Fathers.

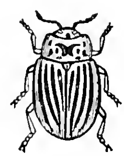
This beetle belongs to the family of leaf-eating Coleoptera (or Chrysomelidæ) of which the common striped squash

FIG. 153.



Doryphora juncta.

FIG. 154.



D. 10-lineata.

beetle is a familiar example. It lays its eggs on the leaves of the plant it inhabits in the larva, or grub, and the adult state; while in the pupal, or inactive, period of its existence it lives in the ground, just under the surface of the soil. Figure 153, from Riley, gives an idea of *Doryphora juncta*, an ally of this insect, in its different stages. All the drawings are of the size of life except *d*, a wing cover, and *e*, representing a leg enlarged; *a* represents the yellowish

*First Annual Report on the Noxious and Beneficial Insects of Missouri, 1869. p. 102.

eggs; *b*, larva fully grown and soon after hatching; *c*, the beetle itself, which is cream-colored, with three black stripes on each wing cover. Figure 154 represents *Doryphora* 10-*lineata*. The larva is pale yellow, with a reddish tinge, and a lateral row of black dots.

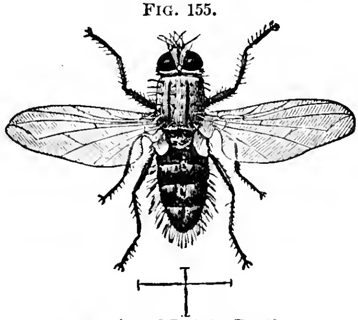
I quote from Mr. Riley's report the following account of its habits. "In the latitude of St. Louis there are three broods during the year, the last brood wintering over in the beetle state under ground. They are usually dug up in the spring of the year in land that had been planted to potatoes the year before. The beetles issue of their own accord from the ground about the first of May, and the last brood of beetles enters the ground to hibernate during the month of October. Though in general terms this beetle may be said to be three-brooded, yet it may be found at almost any time of the year in all its different stages. This is owing to the fact that the female continues to deposit her eggs in patches from time to time, covering a period of about forty days; and also from the fact that among those larvæ which all hatch out in one day, some will develop and become beetles a week and even ten days earlier than others. Thus it may be that some of the late individuals of the third brood pass the winter in the pupa state, though the normal habit is to first transform to beetles. Each female is capable of depositing upwards of a thousand eggs before she becomes barren, and in from thirty to forty days from the time they were deposited, they will have produced perfect beetles. These beetles are again capable of depositing eggs in about two weeks after issuing from the ground, and thus, in about fifty days after the egg is laid, the offspring begins to propagate."

This insect should not be confounded with a closely allied species (*D. juncta*, Fig. 153), which feeds upon the horse-nettle (*Solanum Carolinense*), a wild plant common in the southern and western states. It has not been known to attack the potato. This species differs from the other in

having the third and fourth stripe from the outside united, where they are distinct in the potato beetle, and the legs entirely pale yellow, with a dark spot on the thighs. The head of the larva, or grub, is paler than in that of the potato beetle.

A large number of parasitic and external insect-enemies prey upon the potato beetle, and were it not for these friends

FIG. 155.



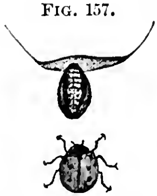
Parasite of Potato Beetle.

of the farmer, he might well despair. The only insect as yet known to live parasitically on the potato beetle is the Lydella (Fig. 155, enlarged), described by Mr. Riley under the name

FIG. 156.

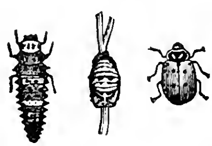
3-banded Lady Bird.

FIG. 157.



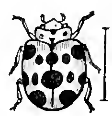
9-spotted Lady Bird.

FIG. 158.



Hippodamia.

FIG. 159.



Chilocorus.

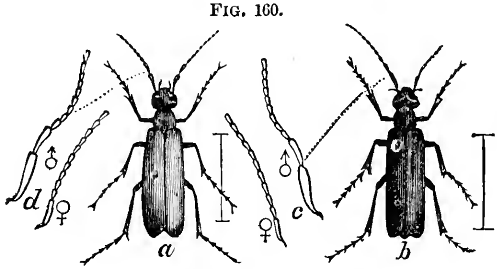
of *Lydella doryphoræ*. He remarks that "this fly destroyed fully ten per cent. of the second brood and fifty per cent. of the third brood of potato beetles that were in my garden."

Of the external enemies the lady birds are among the most efficient. (Fig. 156, *Coccinella trifasciata;* Fig. 157, *Coccinella 9-notata*, all slightly enlarged; Fig. 158, *Hippo-*

damia convergens; a, larva; *b*, pupa; *c*, beetle, natural size; and Fig. 159, *Chilocorus.*) These lady birds destroy the eggs and young grubs, and at times have been so efficient as to save to farmers a large proportion of their crops. On the opposite page are figures of different bugs and beetles which also prey upon the potato beetle, rendering the most efficient service. Of the bugs (Hemiptera) the first two figures* represent certain common forms said by Mr. Riley and others to prey at times voraciously both upon the larva and beetle itself; the remaining figures illustrate certain beetles known to prey upon it.

Some of the governments of Europe are taking measures to prevent this insect from crossing the Atlantic and invading the potato fields of the old world. The Swiss au-

FIG. 160.



Blister Beetles.

thorities are on the alert, and the Belgian government has promptly introduced a bill prohibiting the importation of potatoes from the United States and other countries, as a measure of precaution against the introduction of the Colorado beetle and spread of the potato disease.

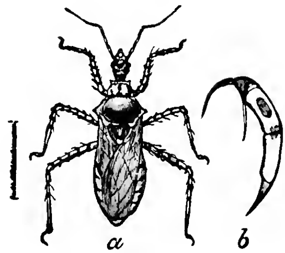
The Blister beetles (Fig. 160, *a*, *Lytta cinerea; b*, *L. vittata*), which have at times ravaged potato fields, are said by Mr. Riley to devour the young of the Colorado potato beetle.

*Fig. 161, *b*, *Arma spinosa; a*, its beak, enlarged; *c*, the beak of *Euschistus punctipes*, a bug otherwise closely resembling Arma. Fig. 162, *Harpactor cinctus; b*, beak. Fig. 163, *Tetracha Virginica.* Fig. 164, *Calosoma calidum.* Fig. 165, *Pasimachus elongatus.* Fig. 166, *Harpalus caliginosus.* (See page 211.)

FIG. 161.

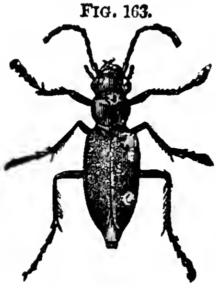
Arma.

FIG. 162.



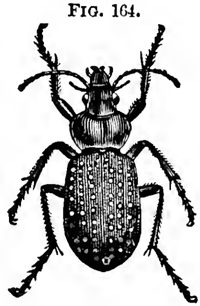
Harpactor.

FIG. 163.



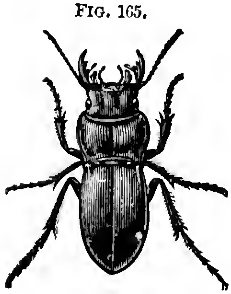
Tetracha.

FIG. 164.



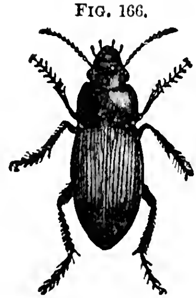
Calosoma.

FIG. 165.



Pasimachus.

FIG. 166.



Harpalus.

Domestic fowl, as well as the quail and crow, and the toad and skunk, devour the grubs and beetles. The flesh of fowls which have eaten them, however, should not be placed upon the table, as the Colorado beetle is poisonous, and taints the flesh. Among the artificial remedies the use of Paris green, one part mixed with five of flour, and sprinkled over the plants dry, or the Paris green alone mixed with water is by far the better, and is now in universal use in the western states.

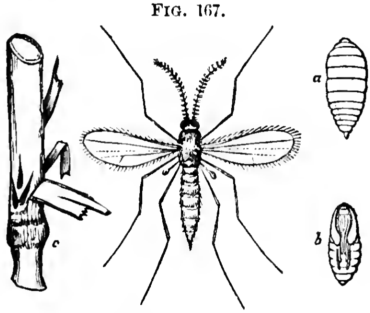
But however well Europe has succeeded in keeping American insect pests out of her borders, the easy-going, slack American farmer witnesses the arrival of European pests without let or hindrance. America is the land of the free, whether of those human pests who leave foreign countries for their country's good, or of their entomological prototypes. The same good-natured indifference and want of intelligent forethought, that let the Colorado beetle travel unimpeded from the Rocky Mountains to the Atlantic coast, looked with unconcern upon the importation of the European currant saw fly into this country, and beheld its rapid spread throughout the east and west.

We were less to blame for allowing the Hessian fly to get a foothold in our land. During the Revolutionary war, before we had gained a nationality, this midge was brought over in straw by the Hessian troops. As early as 1788, at least, this insect, or one exactly like it in habits, as shown by Dr. Harris, was known to be destructive in Switzerland. Harris states that it was "first observed in the year 1776 in the neighborhood of Sir William Howe's debarkation on Staten Island, and at Flat Bush, on the west end of Long Island. The history of its advance inland as given by Harris is a repetition of the mode of naturalization of the European cabbage butterfly and saw fly, known with certainty to be imported insects.

The Hessian fly (Fig. 167, *a*, larva; *b*, pupa) is about

half the size of the mosquito, but differs from it in wanting the long mouth-parts, while the antennæ are more hairy. It is black, with black wings, while the hind body is tawny and the legs are pale red, with black feet. The body is about a tenth of an inch in length, and the wings expand about a quarter of an inch. There are two broods, the flies appearing both in spring and autumn. At these times the fly lays from twenty to thirty eggs in a crease in the leaf of the young plant. Four days after, if the weather be favorable, the young, pale red maggots may be seen crawling down the leaf until, arriving at a joint in the stalk of the plant, they remain head downwards, as at figure 167, *c*,

FIG. 167.

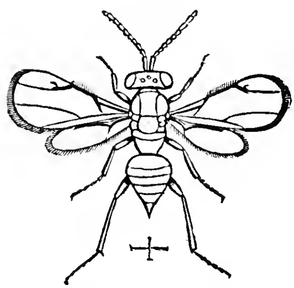


Hessian Fly and young.

under the base of the leaf, where by the simple pressure of their bodies they become embedded in the side of the stem. Two or three maggots thus embedded are sufficient to cause the plant to wither and die. In five or six weeks they mature, and by the first of December their skin hardens and becomes of a chestnut-brown color. This is the so-called "flax-seed" state. The outer larval skin encases the larva, or maggot, whose body is contracted and somewhat changed in form. In this state it remains through the winter. Towards the end of April or early in May, the pupa becomes perfected and by the middle of May in New England escapes from the

pupa-case in which it has been wrapped like a mummy. This occurs just as the wheat is coming up. For a period extending over three weeks they lay their eggs and then disappear. The maggots hatched by the eggs laid by the spring brood assume the flax-seed form in June and July, and are found unchanged in the autumn, most of them remaining in the stubble. This is a most important fact, of which the farmer may take advantage. Now, if the stubble be burned in the autumn, millions of these maggots will be destroyed, and if this process were carried on in every wheat field in the country the ravages of this and other destructive insects would be stayed. As it is now we are almost wholly

FIG. 168.



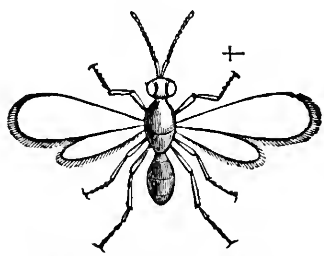
Parasite of Hessian Fly.

dependent on nature's means of preventing their too great increase. Figure 168 shows (much enlarged) a parasitic four-winged Chalcid fly, which has the instinct to thrust its ovipositor through the sheath of the leaf under which the maggot of the Hessian fly lurks, and deposit an egg in its body. Dr. Fitch has suggested that the European parasite of this and the wheat midge should be imported and bred by the quantity, so as to stop their ravages. It would be a simple thing to do. A quantity of stubble from an English or French wheat field could be imported and scattered over the wheat fields of southern New England and the Middle

States, and in this way the parasites with but slight expense be had by the quantity. Why have not commissioners before this been appointed by the several state authorities to attend to this important matter?

While the Hessian fly attacks the root, the wheat midge adopts the ear as its point of attack. When the wheat is in blossom the females lay their eggs in the evening in clusters of from two to twenty, by means of the long, retractile, tube-like extremity of the body, within the chaffy scales of the flowers. The orange-colored maggots appear in from eight to ten days after, and when fully grown are one-eighth of an inch long. They crowd around the germ of the wheat,

FIG. 169.



Parasite of the Wheat Midge.

which by pressure becomes shrivelled and aborted. About the first of August it casts the skin, either while in the ear or after it has descended to the ground. After descending to the earth it spins an earthen cocoon, smaller than a mustard seed, and remains through the winter about an inch under ground. The midge appears the next June and July. Figure 169 represents its most deadly parasite. In dealing with this midge it is obvious that if the wheat field is ploughed after the stubble is burnt off, either in the autumn or spring, great numbers will be cut off, for when buried five or six inches, the fly is unable to reach the surface of the ground. Another method is to sow grain late in the season,

for example, in New England after the 15th or 20th of May. By early sowing the young wheat will have got the start of the flies, and too large and strong for them to kill it.

For a third and often still more destructive insect, which sometimes succeeds in cutting off a half and sometimes nearly the whole of a crop of wheat, oats or barley, we must turn to the very family of parasitic chalcid flies which are as a rule beneficial to agriculture. A few of them make galls in the stems of plants, and the maggots, instead of feeding on the juices of living insects which serve as their hosts, prey on the juices of plants. Such is the famous joint worm or *Eurytoma hordei*. This is a native insect. It is a little, shining, black, four-winged fly, a little over a line in length, with the knees and feet pale yellow. The hind body is attached by a slender pedicel to the thorax, and the male antennæ are provided with tufts or verticils of fine hairs.

When the wheat or barley is about eight or ten inches high, their growth is often checked, the leaves turn yellow, and irregular gall-like swellings arise between the second and third joints of the stalk, or in the joint itself. In November, in New England, the worms transform into the pupa state, living through the winter unchanged in the straw, or remaining in the stubble in the field. In Virginia, where the joint worm has been fearfully destructive, the maggot does not transform until late in February, or early in March. From early in May until the first week in July the flies issue from the galls in the dry stubble and are supposed to immediately lay their eggs in the stalks of the young wheat or barley plants.

From a knowledge of the habits of this insect it is evident that the prudent farmer by coöperating with his neighbors can successfully cope with this insect if he and they are careful to burn the stubble in the autumn and spring, and carry on the process for several successive years over a large

tract of country. Ploughing in the stubble in this case does not injure the insects, as with their hard bodies they can work their way out of the earth. The joint worm has several parasites, members of its own family, and it must be a pleasant sight to the agriculturist, however it may strike the moralist, to see the members of this large family falling upon and destroying one another, and in such an atrocious way, too. Indeed, our sole dependence for protection against noxious insects is the literally intestinal wars by which their numbers are kept down to a moderate figure.

The Army worm of the north is essentially a field insect. It is not usually a common object, but at long intervals it swarms in immense numbers, cutting off acres of wheat, barley, oats and grass. This worm is the caterpillar of the *Leucania unipuncta*, one of the family of night-flying moths, represented by the cut worms (Agrotis, see Figs. 9, 10, 11) and Cucullia, etc. The present moth is rusty grayish ochreous brown, with the wings free from the usual markings, and only a few dark dots forming a row parallel to the outer edge of the wing, with a single white dot near the centre of the wing. She probably lays her eggs near the roots of grasses, such as the timothy and red top, about the middle of June. In the Middle and Western States the eggs are probably laid in April and May, and the moths lay their eggs for a second brood in June and July, while in New England the moth appears in October, and probably then lays eggs which do not hatch till the spring.

The caterpillars on hatching feed for about four weeks, until nearly fully fed, when they stray off to seek fresh pastures. Usually their numbers are inconsiderable, but several times during the last and the present century they have appeared in immense armies. In New York and New England they have occurred in great numbers in 1743, 1770, 1790 and 1817. In southern Illinois they abounded in 1818 or 1820. In 1842 they were very destructive. In 1856 they

appeared in such numbers as to attract general attention, but in 1861, the year in which the writer first made their acquaintance, they were a grievous plague.

A writer in Danvers, Mass., says: "They were seen in great numbers through the entire field of several acres, climbing up the stalks of the barley, eating the blades and cutting off the heads of the grain. The day after these worms were discovered, the barley was mowed in order to preserve it, when they dropped to the ground, throwing themselves into a coil, a habit of the insect when disturbed. Many of them soon commenced a march for the neighboring fields and gardens, while others blindly pushed forward a column across the highways over a stone wall, where they were crushed by travellers on the road. But the main body marched to the adjoining gardens and enclosures, where the proprietors were waiting to receive them in their entrenchments, which had been thrown up a foot wide and two feet deep. The worms, as they fell in their advance into the trenches, were assailed in various ways by eager combatants, some spreading over them lime, tar or ashes, while others resorted vigorously to pounding them. In this way, countless numbers of them were destroyed. The rear guard, composed principally of those of smaller growth, kept in the field, where they were picked up by a troop of fifty young red-winged black-birds. I also noticed the robins feeding on these vermin." Again: "In adjoining lots they were commencing their devastation upon the corn, turnips, cabbages, weeds and grass. They leave the grass ground completely clean and white, so that it has the appearance of having been scorched in the sun. The cabbage and turnips they destroy by eating the tender parts of the plants, while they attack the corn by descending the spindle and concealing themselves in large numbers among the leaves where the corn is to make its appearance. Corn thus attacked looks wilted and drooping. In some hills, the stalks were stripped

of all their leaves. There were no worms upon the potato tops, though they have killed all the grass to the borders of the field."

The name "Army worm" is suggestive of the regular, trained way in which myriads of these caterpillars march together in long, deep columns, side by side, steadily over every obstacle, wherever their food or instinct may lead them. Unlike the cut worms, which move by night, singly, from field to field, and secrete themselves by daytime at the roots of the plants they attack, the Army worm feeds in the forenoon as well as the evening. They may be seen scattered over fields of grain or grass, either devouring the leaves or cutting off the heads and letting them fall on the ground. They will thus eat their way across a field, wantonly mowing off the heads of the grain. In this way in Plymouth county, Mass., they destroyed an acre and a half of wheat in one night, and then attacked a corn field in the same ruthless manner.

This caterpillar appears first in July in Massachusetts, and a month later in Maine, where we saw it at Bangor and northward between the first and middle of August.

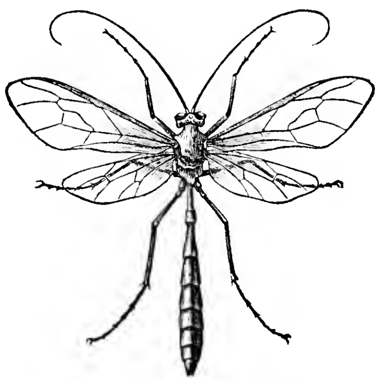
It is about an inch and a half long, like the cut worm in shape. It is dark, with a light, interrupted, thread-like line along the middle of the back; on the sides a light line edged with two thread-like lines, and a light colored, waved line just above the legs.

About the middle of August it descends into the earth, and there constructs a rough earthen cocoon, or contents itself with making a rude cell of dry grass just below the surface, in a day or two after assuming the chrysalis state. Lying here for ten days or a fortnight, the moth flies about at the end of August.

In dealing with this insect, the best remedy is of a preventive nature. If the grass lands and wheat fields are burnt over in autumn multitudes of the moths, or chrysal-

ides will be destroyed. The natural enemies are birds and ground beetles which collect about the rear and van of the moving army. Six species of ichneumon flies prey upon them, among which is a kind of Ophion (Fig. 170). These parasites either attach an egg to the outside of the body of the caterpillar, or insert it beneath the skin. Mr. Walsh, who discovered most of these parasites, also found that a Tachina fly, an insect somewhat like the ordinary house fly, was in Illinois so destructive that out of nearly sixty worms all but two had the eggs of these flies stuck in groups of

FIG. 170.



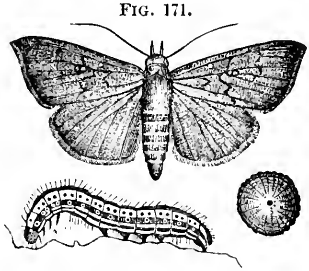
Parasite of the Army Worm.

from one to six on the upper side of the body. From these caterpillars he bred fifty-four Tachinas and only two moths. Such is the effective warfare waged upon one insect by another. In this way the balance of nature is preserved. As to their mode of attack he states that "Jefferson Russell, an intelligent farmer, had repeatedly, on damp cloudy mornings, watched a large bluish green fly, about the size of a blow-fly, attacking the army worm, and depositing its eggs on the shoulders of the victim, as he ascertained by a

double lens. As they were attacked, the army worms kept dropping to the ground and gathering in clusters, or hiding under clods, until finally the wheat on which they occurred was entirely free from them."

The Army worm of the south, or cotton worm, is quite a different sort of caterpillar from its northern namesake. It loops in its gait, and may thus be distinguished from the boll worm, also found upon the cotton. Its body (Fig. 171, moth and larva, natural size; egg, much enlarged) is rather thick in the middle, tapering towards both ends; and it is green, covered with short hairs, and dotted with black along a yellowish line situated on each side of the back, and with black dots beneath. The moth is reddish brown, the wings quite free from the markings usual in the group to which it belongs; the fore wings are triangular, with two indistinct, dark, zig-zag lines, with a conspicuous dark spot near the centre of the wing, in the middle of which are two white dots.

FIG. 171.



Cotton Worm, egg and moth.

She lays from four to six hundred low, flattened, greenish eggs, ornamented with vertical ribs, placing them upon the under side of the leaf. In from two to ten days the young worms hatch, and begin to feed on the pulpy portion of the leaf, but as they grow larger they devour the entire leaf as well as the buds and blossoms. During their life as caterpillars, which only lasts from fifteen to twenty days, they cast their skins five times. As regards the habits of the cotton worm I cannot do better than to quote from Mr. Riley's second Report on the Noxious Insects of Missouri, in which he says that "there are three different broods of worms during the year, the first appearing in June or July, and the, last, which does the most damage, appearing in

August or September, or even later. Mr. Lyman, in the little work already referred to, says: "That nature has made no provisions by which either the fly, the worm, the chrysalis or the eggs, can survive the winter or exist for any length of time where the cotton plant is not a perennial." But this is surely an error, which Mr. Lyman would never have made, had he possessed a better knowledge of insect life; and as Mr. Glover found that the chrysalis was killed by the slightest frost, the insect evidently winters over in the moth state, as do many others belonging to the same tribe. Mr. W. B. Seabrook gives strong evidence that this is the case, in a "Memoir on the Cotton Plant," read in 1843, before the State Agricultural Society of South Carolina, wherein he says: "That the Cotton Moth survives the winter is nearly certain. An examination of the neighboring woods, especially after a mild winter, has often been successfully made for that purpose." And Dr. Phares states positively that "the moth hibernates in piles of cotton seed under shelter, under bark and in crevices of trees in dense forests and other secluded places, and that it may often be seen on pleasant days in winter."

While this worm is young and small it does not seem to attract attention, but early in the autumn it suddenly becomes abundant, and at certain years extremely destructive. One of these visitations, which fell under the observation of the eminent botanist, Professor J. Darby, of Auburn, Alabama, is thus described in a letter to the writer: "Saturday, September 19th, I was in the field examining the forms (buds before flowering) and the young bolls (fruit after the floral organs have fallen off). I examined all carefully, with no signs of eggs or worms. On Sunday I did not see it. On Monday I passed it as usual and observed nothing unusual. On Tuesday morning I passed it and noticed nothing unusual. On Tuesday noon every plant in the field was stripped of all its upper leaves; not one remaining as

far as could be seen, and the plants were covered with millions of worms. I counted on one plant forty-six worms. They commence at the top of the plant, eating every leaf. When the leaves were gone they attacked the young bolls, eating through the perianth and consuming the young cotton. In the course of four days the work was done. They did not touch the grape or any other plant in the field, so far as I have been able to see. Many left the field, and thousands were in the road and on the fences, but not one in a thousand thus escaped. To-day, September 23d, there is scarcely one to be seen. Their disappearance is as mysterious as their coming. They have left no signs that I can see, either on the stalks or in the ground. They have extended over hundreds of miles, and nothing has proved a barrier to them, having been as destructive on islands in the river, as elsewhere. One-third of the cotton crop has been destroyed. Nothing of the kind has occurred in thirty years past to my knowledge."

After the caterpillar has become fully grown, it draws a leaf around it, and then changes to a chrysalis. It remains in this state for one or two weeks, when the moth escapes.

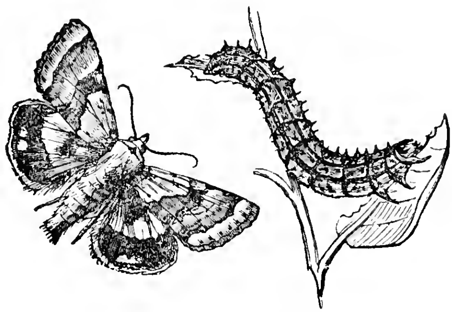
In dealing with this insect, the only practicable way to diminish its powers of doing mischief is for all the cotton planters to combine and employ hand-picking, looking over the leaves for the eggs when the moths lay them, and again picking off the worms when they are detected. The use of carbolic acid, cresylic soap-suds and other washes have been recommended.

This insect seems to appear wherever cotton is raised. It is very destructive in the West Indies and in South America, and either this or a similar insect occurs in Egypt. It is also sometimes found in New York, and I have taken several specimens late in the summer on an island in Salem harbor, Massachusetts. Mr. Grote thinks that away from the Gulf States the whole brood dies every year, and that

the caterpillars of the next summer come from eggs laid by moths which have flown north from the Gulf States. This is not, however, in accordance with the habits of moths generally, and we shall expect to find that the moth winters over in the middle and northern states, where it is a straggler, as well as in the southern states. It will be interesting to know on what plant the caterpillar feeds north of the cotton states.

The boll worm (Fig. 172, moth and larva) is more like the cut worm in appearance. It feeds on the boll of the cotton plant, the moth laying her eggs singly up to the number of five hundred on the calyx of the plant. The caterpillars appear in three or four days. They pierce through the calyx and destroy the flower buds. When fully fed it makes an oval cocoon just under the surface of the soil, where it remains in the pupa state three or four weeks. There are two broods of this worm in the Middle States, three in Georgia. The last brood issue as moths in November, though, unlike the Army worm, some remain under ground through the winter.

FIG. 172.



Boll Worm and Larva.

9. Insects of the Forest.

THE insects of the forest comprise a large proportion of the entomological riches of the world. Those countries which have the most extensive forests have the greatest number and variety of insects. The tropics, particularly Brazil and the East Indies, sustain the richest assemblage of insect forms in the world. Their number and beauty diminish as we go north or south. Luxuriance of forests with great heat and moisture produces the widest diversity of forms and richness of hues. A large proportion of the insects sent home by collectors from tropical countries are the butterflies and large showy moths, with boring beetles, the Scarabeids preying on rotten trees, timber beetles of all descriptions, and the parasitic or predaceous forms which keep them in check. In the tropics when a tree dies it must be removed to make room and supply food for the growth of others. A wound made by some accident, such as the fall of an adjoining tree, the browsing of deer or bears, the gnawing teeth of mice or rats, leaves a scar, a weak place, which is immediately utilized by some boring insect as a place to deposit its eggs. Borers and timber beetles of many different kinds, with varied modes of attack run their galleries under the bark, or bore into the sap wood or straight into the heart of the tree. Their presence invites a horde of smaller invaders. Their parasites seek them and fall upon them until the tree and perhaps its neighbors are thoroughly worm eaten, when a tornado rushes through the forest and leaves its track behind, marked by a holocaust of fallen trees. Now these must, by the natural forestry practised on a gigantic scale in nature, be removed. Squads of Hercules beetles, Passali, and other devourers of decayed

wood, luxuriate in the mouldering trunks. In an incredibly short space of time, aided by ants and Termites, the prostrate trunks are converted by the alchemy of nature into a mound of soil crowned by ferns and climbing plants, out of which will spring a new growth to take the place of the former generation. Many tropical trees are flowering plants, and immense throngs of gaudy Cetonias, Goliath beetles, and others of smaller stature frequent the blossoms for pollen, and fertilize the flowers of the trees. Nature, lavish of her ornaments in the tropics, hangs her stateliest trees with climbing vines, creepers and strange, bizarre orchids which attract multitudes of hawk moths and butterflies, whose gay colors light up the sombre glades of the primitive forests. Thus the forests are populated with hundreds of thousands of insect forms.

So luxuriant and rapid is the growth of forests in the tropics that they apparently are in the aggregate little affected by the ravages of insects. The latter on the whole rather serve to prune and check the growth of portions of the tree, to weed out the weaker, imperfect individuals and aid in the development of the stronger, and when a tree shows signs of decay to at once raze it to the ground and convert it into the soil from which it sprang.

Not so in the temperate regions of the earth, where man in subduing the forest exceeds his commission and well nigh exterminates it, leaving but scattered patches of the original forest primeval. In travelling through the pine forests of northern Maine, where the lumberers have made great gaps in the ranks of sturdy trees which formerly crowded the banks of the Kennebec, Penobscot, Alleguash and St. John, one may walk through the woods for miles and be struck with the poverty of insect life. Let him in a warm July or August day come out into a clearing where the lumberer's camp or lonely farm house is shaded by scattered trees, and he will be astonished at the number and variety of insect

forms. Brilliant green and golden Buprestids may be seen sunning themselves on the trunks of the trees, and the olive green Monohammus beetles so destructive to pines flying among the trees or emerging from their holes in the trunks. The Urocerus, a saw-fly like the Tremex, one of the characteristic insects of pine forests sails around in its circling flight, and pine weevils and timber beetles open their wings in the heat of the sun. The weeds, nearly all of European origin, crowd out the aboriginal inhabitants, and with their rank growth hedge about the cabin. With them have arrived the usual proportion of imported insects, but most characteristic of the northern forests are the Arthemis butterfly, the banded Buprestis, the pine weevils, the russet geometrid moth and others.

If the destruction of forests goes on as rapidly as at present all these forest insects will soon have lost their occupation. We shall then have to plant new forests, as they have and are doing in portions of northern Italy, in Austria, Germany and Great Britain. When this is done and the young trees are growing in extensive plantations, the danger arising from the ravages of destructive insects will be very great. As in Europe, we shall have to make chairs of forestry in our agricultural colleges, and appoint commissioners of forests. Then, if not at the present day, a thorough and practical knowledge of forest insects will be one of the guarantees to success in the cultivation of trees. At present Germany leads the civilized world in the intelligent care of her replanted forests. How carefully the trees are nurtured, how intelligently their diseases are studied, and with what pains the habits and forms of the destructive insects are described and drawn, is well known. The elaborate and beautifully illustrated works of the late Dr. Ratzeburg have made his name famous, and they form a perpetual witness to the intelligence and forethought of the people who encourage by their patronage the publication of such expensive and

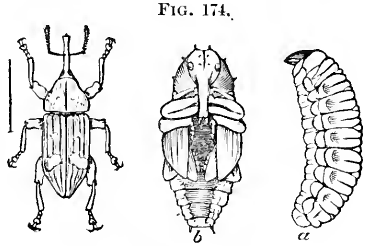
richly illustrated works. Such a work as that of Ratzeburg entitled "Animals Injuring Forests," has a double value. Not only is it of high practical importance, but the minute information therein contained regarding the habits of the destructive insects and their many parasites, the relation of the trees themselves to the animal world, the peculiar diseases resulting from their attacks, the deformities and changes wrought not only in single trees, but extended through large tracts of forest, all bear on theoretical points in biology, such as the supposed struggle for existence in organized beings, the origin of sports, strains, races, varieties and species, which combine to lend the highest interest to such stores of facts as are to be found in the works of this learned German.

Let us now walk through the pine woods, and notice the work of some of the more remarkable insects. I could take the reader by a favorite walk in the pine woods of Maine, and show him among a splendid growth of tall, straight, white pines, one enormous tree whose girth twenty feet from the ground is between fifteen and twenty feet. Above that the trunk divides into four branches, curved outwards at their base, forming a double crotch. In another walk I could show him several large trees, all within a few rods of each other, variously gnarled and distorted, either with single curved trunks, or double or triple-headed monsters, specimens of vegetable monstrosities which would delight a Geoffrey St. Hilaire or Dareste.

What is the origin of this deformation? It is a common little weevil which has the habit of laying its eggs late in the spring in the terminal shoots of white pine bushes. Several grubs hatch out and burrow in various directions under the bark. As they grow apace they sink into the wood, as far as the pith, and by the end of the second summer, according to Professor Peck, as quoted by Harris, they have each made a little cell in the wood, cleverly lined with pine

chips, in which the grub changes into a chrysalis. It is easy to find a stem of the pine containing a dozen or more of these cells, situated at quite regular intervals under the bark, now loosened or peeling off. If we examine it in the autumn we shall find the grubs, their pupæ, or chrysalides, together with the beetles. The accompanying excellent figures (174) of the pine weevil, its young and chrysalis or pupa, the two latter magnified three times, will give an excellent idea of the different stages of growth of this weevil. The footless grub is white, with a honey-yellow head. The white pupa has a mummified look, with its eyes partially concealed by its wings, and its legs folded on its breast. In this attitude it lies in its cell or sarcophagus awaiting the

FIG. 174.



Pine Weevil; *a*, grub; *b*, pupa.

dawn of a new life in the outer world. It either presses out from under the bark and seeks some other hiding place, or lies in its cell until some warm day in April, when with a troop of its fellows it flies about in the sunshine, busied with the care of providing for the continuance of its race.

Now this work of tunnelling and mining causes the death of the terminal shoot of the young tree. The bush sends out lateral shoots, more or less crooked. One can see plenty of them in the course of any walk in the edges of the woods. Thus deprived of their leading shoot such dwarfed and gnarled bushes grow up and vastly injure the appearance of the forest, and its value as lumber.

Dr. Fitch says that "young thrifty-growing pines are its favorite resort, and among these it selects those that are most vigorous, and whose topmost shoot has made the greatest advance the preceding year. But I have seen it so numerous that not only the topmost shoots of every tree in the grove, but many of the lateral ones also were invaded and destroyed by it. * * * The tree that is attacked continues its growth upward during the fore part of the season as usual, sending out from the summit of the shoot that is infested a leading shoot with a number of lateral branches around its base. But the growth of these new succulent twigs is arrested and they begin to wilt and wither about the middle of July, the worms having by this time become so large, and mined and wounded the stalk below to such an extent that its juices are exhausted, and it fails to transmit any nourishment to these tender green shoots at the summit, which consequently dry up and perish."

Here again the forester is aided by his best friends, the birds, which pick out the grubs and eat them. There are also several parasitic insects which further reduce their ranks.

Another pine weevil, equally abundant and often as destructive, is the Hylobius. It is a larger beetle, and darker, less reddish than the white pine weevil (*Pissodes strobi*). It is particularly destructive to the pitch pine, so much so in the southern states that Wilson, the ornithologist, thus speaks of its depredations near Charleston, South Carolina, as quoted by Harris. "Would it be believed that the larvæ of an insect, or fly, no larger than a grain of rice, should silently, and in one season, destroy some thousand acres of pine-trees, many of them from two to three feet in diameter, and a hundred and fifty feet high? Yet whoever passes along the high road from Georgetown to Charleston, in South Carolina, about twenty miles from the former place, can have striking and melancholy proofs of the fact. In

some places the whole woods, as far as you can see around you, are dead, stripped of the bark, their wintry-looking arms and bare trunks bleaching in the sun, and tumbling in ruins before every blast, presenting a frightful picture of desolation. Until some effectual preventive or more complete remedy can be devised against these insects, and their larvæ, I would humbly suggest the propriety of protecting, and receiving with proper feelings of gratitude, the services of this and the whole tribe of woodpeckers, letting the odium of guilt fall to its proper owners."

Not remotely allied to the weevils, which are distinguished by their more than Roman noses, are the little snub-nosed cylindrical timber beetles. Their hard bodies, short legs and strong jaws admirably adapt them for boring in the bark and solid wood of trees. They are sometimes called wood-engravers. They may well be styled animated gimlets, as they bore straight, even and true holes, as if driven by the hand of a carpenter.

FIG. 175.

Wood Engraver.

There are several species which have different modes of assault. The first is the *Tomicus xylographus* (Fig. 175), the true wood engraver. It is quite small, chestnut-colored, about a line in length, its wing-covers are bevelled off at the tip, the edges of the declivity being armed with four or five teeth on each side. The female mines the outer surface of the sap wood and inner layer of the bark, lengthwise to the tree. Curiously enough there are more males than females and they help their partners, each working in turn. This is one of the few cases among insects in which the two sexes unite in the work of providing for the welfare of their future offspring. The female is said by Dr. Fitch, from whose admirable observations I am compiling this account, to make little notches at intervals along the burrow. In each of these notches from one to four eggs are placed. As the beetles,

clothed with the short, stiff hairs which cover their bodies, pass backwards and forwards in their burrow, they brush the dust and chips into the notches, thus covering the eggs up.

When they hatch the young grubs gnaw their way straight out for two or three inches from the primary tunnel, which may be from four to eight inches in length. It has been noticed that the burrows are always separate, never touching or crossing each other. When about to pupate, *i. e.*, change to a pupa, the grub sinks deep into the wood at the outer end of the burrow. This species attacks the pine when in perfect health.

Another wood engraver, nearly two lines in length, is the *Tomicus calligraphus*. It makes short, large, irregular burrows, and is common in the yellow pines of the Carolinas, as well as the pitch pine of the northern states.

The burrow of the *Tomicus pini* is like a bird's claw, or the fingers of a hand. As the beetle is a line and a half in length its burrows are rather larger than usual.

FIG. 176.

Tunnel of Timber Beetle.

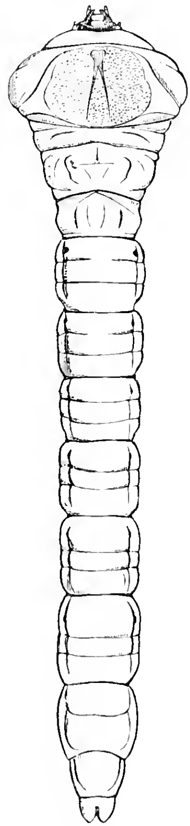
The smallest form known is the *Tomicus pusillus*, slightly more than half a line in length. It mines extremely fine, slender, wavy passages in every direction, mostly in the wood. The eggs are laid so that the young grubs mine outwards, travelling away from each other.

In the bark beetles there are several males to one female at work in a mine. We now come to the true timber beetles, which sink their tunnels deep into the wood. Here the females are most numerous, and are probably not aided in their work by the males.

The *Tomicus materarius* is a line and a half long, and reddish-yellow in color. It makes a straight burrow, with regular secondary tunnels running out at right angles to the main one, somewhat as in Fig. 176. Its presence may be known by the clean white piles of borings it throws out of its hole.

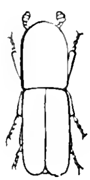
A very slender form is the wine cask borer (Fig. 177), which acts as a state constable, slily emptying the wine out of casks, or previously rendering them unfit for use by metamorphosing them into sieves through the transforming power of its jaws. To show how abundant these insects may become, a piece of elm three feet long, bored by the *Scolytus destructor* of Europe, was estimated to have contained 280,000 larvæ, while the *Tomicus monographus*, which does much mischief by drilling holes in malt-liquor casks in India, has been thought to bore as

FIG. 179.



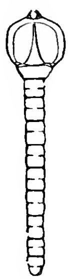
A giant borer, natural size.

FIG. 177.



Wine cask borer, enlarged.

FIG. 178.



Chrysobothris larva.

many as 134,000 holes in the staves forming a single cask. These little beetles, when soft, fleshy grubs, are attacked by multitudes of the young of carnivorous beetles, such as Staphylinus and Hister and their allies.

Often in walking through the woods one's attention is attracted by large flakes of bark peeling off the trunks of pines. They are loosened by the gnawing teeth of grubs, such as are figured here (Fig. 178, a Chrysobothris larva, and 179,

the larva of *Euchroma columbica*, from Central America). It will be noticed that the body is broad and flattened just behind the hard, horny head, while behind the enlargement the body becomes narrow and cylindrical. It thus bores broad, shallow grooves between the bark and the solid wood, consuming the sap wood, the vital part of the tree.

Our largest and most abundant borer of this group is the *Chalcophora Virginiensis*. It is an inch or more in length, the body rough and hard and dark steel brown, with a brassy or coppery hue. It may be observed flying about on hot days in May and June, or sunning itself on the trunks of pine trees.

The grub forms a long, shallow groove, more or less serpentine in its course. As the young borer grows its track increases in width, which is stuffed with chips finely packed behind it. Finally when fully grown and ready to transform it bores a large oval hole deep in the wood, where the insect reposes during its pupal sleep. The insect lives one year as a larva.

Another species (*C. liberta*) is rather smaller, but very similar to the Virginian Chalcophora, and when at rest resembles the young fruit cones. The beetle itself eats the young buds of the pine. Pine saplings are much injured by the larval Chrysobothris, which girdles the trunks and branches.

When passing, in our strolls among the pines, some veteran tree whose days of usefulness have departed, and which already show signs of decay, our ears are often saluted with a harsh creaking noise issuing from the tree. The strain is intermittent and sometimes several voices join in a chorus of harsh, crepitant sounds. It is difficult at first to fix upon the exact site of the choristers, but on pulling off a piece of the bark, out tumble two or three large shining white worms, which tell the story. They are the young of the common

pine borer (*Monohammus notatus*), whose creaking noise we often notice in passing by piles of white pine wood, and sometimes hear issuing from some chair or table or chest of drawers, in which it has remained while they are passing through the saw mill and carpenter's shop on their way to the chamber or kitchen. Its mysterious creaking noise naturally occasions a good deal of speculation as to its source. One sometimes finds the beetle in sawn and planed lumber lying in its cell, or it may issue from the leg of a table or bureau drawer, with its long legs and horns like a ghost from another world, when its advent causes nearly as much of a flutter in the heart of the housekeeper as would the appearance of a veritable spirit.

I have found these larvæ in July in abundance, when they were a little over an inch long, and had apparently completed their first year. I was unable to find any beetles or chrysalides, and am disposed to think that they produced the noise by rubbing their hard, smooth, horny heads or jaws against the sides of their burrow. Dr. Fitch, however, states that the beetle itself makes the noise, and it is evident that both larva and beetle produce a similar sound. I will quote his statement entire. "On a still summer's night the peculiar grating or crunching noise which the larvæ make in gnawing the wood may be distinctly heard at a distance of eight or ten rods. That the insect does not open a passage out of the wood whereby to make its exit until it attains its perfect state, I infer from the fact that several of these beetles gnawed their way out of one of the pillars of the portico of a newly built house in my neighborhood, some years since, the noise being heard several days before they emerged, and whilst they were still at some distance in the interior of the wood."

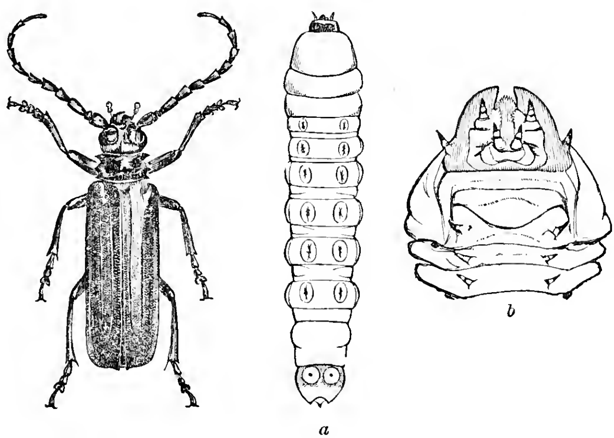
The grub is nearly cylindrical, white and soft, with numerous fine reddish hairs. The second segment of the body is flattened and larger than the others; the succeeding rings

are very short, with a transverse oval, rough space in the middle of the upper and under side of the body.

Its burrow is large, and winds around under the bark, finally sinking into the wood, where the grub undergoes its transformations into a beetle, which has remarkably long feelers, and is of a granite gray color. By its habit of tunnelling logs it is an annoying insect to lumberers, who remove the bark from the logs in order to free the wood from its attacks.

Similar to this beetle, with antennæ twice as long as its body, is a beautiful olive green species, with a white spot on

FIG. 180.



Orthosoma, grub, with head and thoracic rings enlarged.

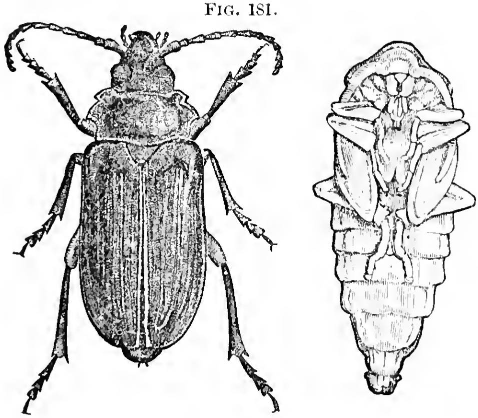
the scutel at the base of the wing-covers. It may be seen flying about white pine bushes in June, when it lays its eggs. It is particularly abundant in the woods around Lake Superior.

Somewhat related to these cylindrical-bodied beetles is the chestnut-colored *Orthosoma cylindricum* (Fig. 180; *a*, larva; *b*, head and thoracic rings), whose grub may often

be found in rotten pine stumps. The beetle itself occasionally enters our houses at night. Pine stumps are excellent breeding places for this and the borer of the large black Prionus beetle (Fig. 181, beetle and pupa), which occasionally leaves its native pine and cuts down our young plums, pear trees and grape vines.

As an example how forest insects may by their widespread ravages change the entire appearance of a landscape, I may cite the case of the injury committed one season in a growth of young pine saplings, or rather bushes, about six

FIG. 181.



Prionus and pupa.

feet high. For several square miles their tops had turned yellow, as if they were dying at the roots. But near the tops were exudations of pitch, forming large masses. On cutting these off, a little caterpillar was found in a hole beneath the pitch, and this was without much doubt the secret of the mischief. It seemed at the time impossible for one or two little caterpillars to do such injury to a large and flourishing bush. I have not since seen such an unusual fatality in young pitch pines, nor this caterpillar, and am now inclined to think that the mischief was produced by the

little caterpillar, the more since similar damage is caused to pine bushes in Europe by a little Tortrix, with similar habits.

A not uncommon sight in isolated pine trees is a nest of saw-fly caterpillars, whose sawdust-like castings form a large mass collected among the leaves. These "false caterpillars," as they are called, are social and live huddled up together on the end of a pine branch. Small trees are often ruined by them.

It always seems as if artificially planted forests suffer the most from the attacks of injurious insects. One of these saw flies, before unknown to science, has been found ravaging a plantation of young pitch pines on Cape Cod. By means of the saw-like ovipositor these curious flies are able to cut slits in the leaves and stems of plants. The present species (*Lophyrus pini-rigidi*) thus slits, and inserts an egg in each side of the needle of the pine. The males are easily distinguished from all other saw-flies by the beautifully pectinated antennæ and shining black bodies.

We could go on describing the insects injurious to our pine trees, but the enumeration would be tedious to the reader. About a hundred different species are known to prey on our native pines, and a number of them attack the imported ornamental pines and firs of our lawns. They attack the roots, the trunk, the leaves and the seed in the cones. M. Perris, a French naturalist, has written an extensive work on the insects of the maritime pine of France, describing with care a hundred species found on that tree alone; and not only the destructive kinds, but all the numerous parasitic and carnivorous forms which take up their abode beneath the bark of the tree and wage a ceaseless warfare against the primitive occupants. If any one would like to look behind the scenes and witness the struggle for existence going on under the bark of a pine tree, let him go to the woods for himself and study the various insects, in-

cluding many spiders, mites and thousand-legs which congregate in these retreats.

Now turning our steps towards the hard wood growths we shall find that the oak harbors a great number of insect inhabitants. We could enumerate from thirty to forty different kinds injurious to the oak in the northern states. The walnut is infested by a still larger number, fully seventy species. The elm struggles against the attacks of about twenty-five different kinds, while the locust and maple have a less number of species specially injurious.

The oak suffers from the attacks of numerous gall-flies, which, not content with deforming the branches and leaves with unsightly tumors, sting even the roots, producing excrescences like ground nuts on the smaller rootlets. These little root gall-flies are wingless and look like little black ants. They are, strange to say, found only early in winter on the snow. They are rare and more curious than destructive.

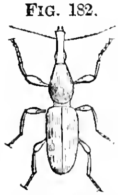
If one will examine a pile of freshly cut red oak wood he will find the sticks of cord wood pretty thoroughly riddled with large holes and tunnels, nearly half an inch in diameter. This is the work of a large fleshy caterpillar, the young of the Cossus. It is the most destructive of all the insects feeding upon the oak, as after the worm is hatched,—and there are a good many of them, since the female lays about three hundred eggs,—they bore directly into the heart of the tree, leaving a passage for the rain and moisture, which aid in the work of destruction. The caterpillar is thought to be three years in attaining its full size, its life being an unusually long one, as few caterpillars are known to live longer than one season. It also infests the locust tree.

If a favorite shade tree has been attacked, the best way to prevent farther mischief is to soap the trunk in June and July, and thus prevent the moth from depositing its eggs, or after the holes appear to plug them up in order to keep the water out.

Another borer is the Brenthian weevil (*Eupsalis minuta*, Fig. 182). By means of its long snout, armed with short, stout jaws at the end, it bores a hole through the bark, inserts an egg, and the grub hatching out bores into the solid wood, finally making a burrow about a tenth of an inch in diameter.

Mr. Riley has described and figured, in his "Sixth Report on the Noxious Insects of Missouri," the transformations of this interesting beetle. He draws attention to the combative nature of the males in the following words. "The males of the Brenthians are known to fight desperately for the female, and, as it has been remarked by Mr. A. R. Wallace,* it is interesting, 'as bearing on the question of sexual selection, that in this case, as in the stag beetles, when the males fight together, they should not only be better armed, but also much larger than the females.' The eggs are deposited during the months of May and June, and perhaps later, the female boring a cylindrical hole with her slender snout, and therewith pushing her egg to the bottom of the hole, as is the habit of all snout beetles. Mr. Howard thus describes his own observations on these insects. 'It requires about a day to make a puncture and deposit the egg. During the time the puncture is being made, the male stands guard, occasionally assisting the female in extracting her beak; this he does by stationing himself at a right angle with her body, and by pressing his heavy prosternum against the tip of her abdomen; her stout forelegs serving as a fulcrum, and long body as a lever. When the beak is extracted, the female uses her antennæ for freeing the pinchers or jaws of bits of wood or dust, the antennæ being furnished with stiff hairs, and forming an excellent brush. Should a strange male approach, a heavy contest at once ensues, and continues until one or the other

FIG. 182.

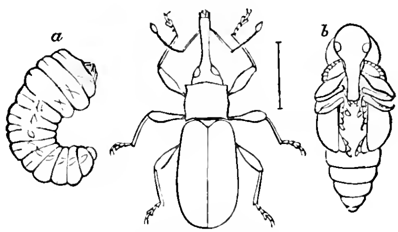


Eupsalis.

*The Malay Archipelago, p. 482.

is thrown from the tree. The successful party then takes his station as guard. These contests sometimes last for hours, and are always repeated if the proper male is defeated, though not often if he is successful. I think it is by mere 'happen so' that the stranger passes by or runs across the busy couple, and if successful in routing his rival he takes the same care of the female as did the vanquished individual. The habits of these insects are much like those of the Curculio family. When disturbed they fold themselves up as well as they can and drop to the ground, where they

FIG. 183.



Oak weevil and young.

feign death. They will soon 'come to,' and hide beneath pieces of bark, stones or other rubbish, Curculio-like."

Another weevil, which may be found in all its stages of larva, pupa and adult, early in May under the bark of decaying oaks, is the *Magdalinus olyra* (Fig. 183; *a*, larva; *b*, pupa, enlarged three times.

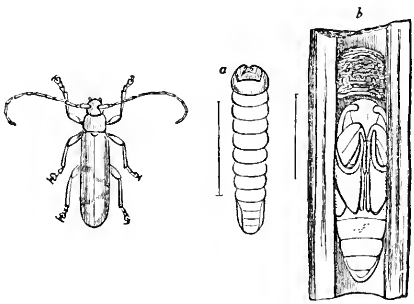
The most interesting and intelligent of all the borers is the oak Pruner (*Stenocorus putator*, Fig. 184; *a*, larva; *b*, pupa lying in its hole). The beetle appears in June and deposits its eggs near the axilla of a leaf stalk or small twig, or in the bark of larger branches. The grub hatches, and sinks into the centre of the twig. Now comes the strange part of its history, in which this grub evinces a most unusual trait in these boring insects. When half grown it nearly cuts the branch off. It then withdraws

into the hole in the portion of the branch beyond the cut, and plugs up the opening behind it before the limb is broken off by some strong wind and falls to the ground.

But as I am already indebted to Dr. Fitch for most of the facts regarding this intelligent insect, I will let him tell them in his own words.

"The worm being about half grown is now ready to cut the limb asunder. But this is a most nice and critical operation, requiring much skill and calculation, for the limb

FIG. 184.



Oak Pruner.

must not break and fall whilst he is in the act of gnawing it apart, or he will be crushed by being at the point where it bends and tears asunder, or will fall from the cavity there when it breaks open and separates. To avoid such casualties, therefore, he must, after severing it, have time to withdraw himself back into his hole in the limb and plug the opening behind him, before the limb breaks and falls. And this little creature accordingly appears to be so much of a philosopher as to understand the force of the winds and their action upon the limbs of the tree, so that he can bring them into his service. He accordingly severs the limb so far that it will remain in its position until a strong gust of wind strikes it, whereupon it will break off and fall.

"But the most astonishing part of this feat remains to be

noticed. The limb which he cuts off is sometimes only a foot in length and is, consequently, quite light; sometimes ten feet long, loaded with leaves, and very heavy. A man by carefully inspecting the length of the limb, the size of its branches, and the amount of foliage growing upon them, could judge how far it should be severed to insure its being afterwards broken by the winds. But this worm is imprisoned in a dark cell only an inch or two long, in the interior of the limb. How is it possible for this creature, therefore, to know the length and weight of the limb, and how far it should be cut asunder? A man, moreover, on cutting a number of limbs of different lengths so far that they will be broken by the winds, will find that he has often miscalculated, and that several of the limbs do not break off as he designed they should. This little worm, however, never makes a mistake of this kind. If the limb be short, it severs all the woody fibres, leaving it hanging only by the outer bark. If it be longer, a few of the woody fibres on its upper side are left uncut in addition to the bark. If it be very long and heavy, not more than three-fourths of the wood will be severed."

"Having cut the limb asunder so far that he supposes it will break with the next wind which arises, the worm withdraws himself into his burrow, and that he may not be stunned and drop therefrom should the limb strike the earth with violence when it falls, he closes the opening behind him by inserting therein a wad formed of elastic fibres of wood. He now feeds at his leisure upon the pith of the main limb, hereby extending his burrow up this limb six or twelve inches or more, until he attains his full growth, quietly awaiting the fall of the limb, and his descent therein to the ground. It is quite probable that he does not always sever the limb sufficiently in the first instance for it to break and fall. Having cut it so much as he deems prudent, he withdraws and commences feeding upon the pith of the limb

above the place where it is partially severed, until a high wind occurs. If the limb is not hereby broken, as soon as the weather becomes calm he very probably returns and gnaws off an additional portion of the wood, repeating this act again and again, it may be, until a wind comes which accomplishes the desired result. And this serves to explain to us why it is that the worm severs the limb at such an early period of his life. For the formidable undertaking of cutting asunder such an extent of hard woody substance, we should expect he would await till he was almost grown and had attained his full strength and vigor. But by entering upon this task when he is but half grown he has ample opportunity to watch the result, and to return and perfect the work if he discovers that his first essay fails to accomplish the end he has in view.

"Thus the first part of the life of this worm is passed in a small twig branching off from the main limb. This is so slender and delicate that on being mined as it is by the worm and all its green outer end consumed, it dies and becomes so decayed and brittle that it is usually broken off when the limb falls, whereby it has escaped the notice of writers, hitherto. The remainder of his larval life is passed in the main limb, first cutting off this limb sufficiently for it to break with the force of the winds, and then excavating a burrow upwards in the centre of the limb, both before and after it has fallen to the ground, feeding hereon until he has grown to his full size."

Fitch adds that "not only the limbs, but small young trees, at least of the white oak, are sometimes felled by these insects; in which cases the worm instead of cutting the wood off transversely, severs it in a slanting or oblique direction, as though it were aware the winds would prostrate a perpendicular shoot more readily by its being cut in this manner."

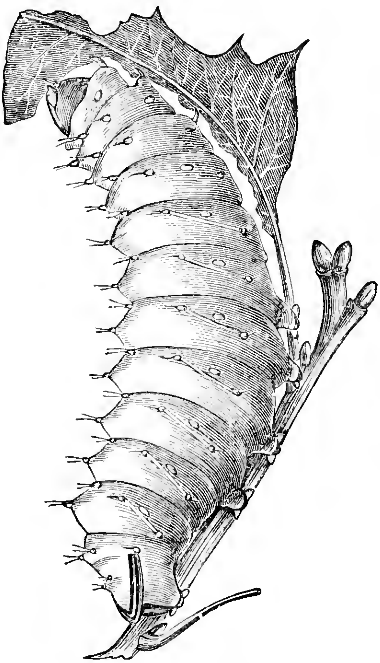
The larvæ become fully grown in the autumn, and some

change to pupæ in the autumn, while others wait till the following spring. The beetle appears in June.

Now in the remarkable habits of these insects, we find a variation in their mode of working corresponding to some difference in the size and nature of the branch in which they live. This is something quite different from the blind, unvarying instinct usually ascribed by the unthinking to the lower animals. The oak pruner selects a fitting place in which to lay its eggs, and because it does so for generation after generation, no one can deny that there was not a time when this habit was in process of formation, and gradually established after a course of experiments continued through, perhaps, many generations. Again, the borer itself is not entirely the creature of circumstances; there is some room left for the exercise of what we may call judgment. The incision it makes in the branch varies in depth with the size of the branch, and it must exercise a certain, be it a minimum, amount of reason to adjust its life with the physical forces about it, in order that the life of the species may be maintained. Doubtless it makes many mistakes, many branches falling too soon or not falling at all; many deaths occurring from these mistakes. Unfavorable seasons, calm weather, a too dry or too moist atmosphere, its parasites, all conspire to reduce its numbers and render its struggle for bare existence exceedingly precarious. But this is the history of every species of animal. The life of each species is a record of mistakes, and disease and often death in consequence of those mistakes. And turning to the human species, the philosophic historian of his race is forced to confess that it is often by their misfortunes that races as well as individuals of marked individualism have moulded their characters. We submit, then, that these unusual instinctive acts of the oak pruner have been in all probability gradually acquired, after many trials, mistakes and failures, until the peculiar habits distinguishing this species from its allies

have become moulded into a comparatively inflexible mode of life, when the creature is governed by what commonly goes under the name of "instinct," a term too frequently used to cover our ignorance and stifle free inquiry into the origin of the different psychological traits of different races of animals.

FIG. 185.



American Silk Worm.

The leaves of the oak are often ravaged by the young of the senatorial moth, a gayly caparisoned caterpillar, with two horns arising directly behind the head. It is nearly two inches in length, black, with four yellow stripes along the back, and two on each side. It lives in clusters on the trees, sometimes well nigh stripping them of leaves in September and October, the large, handsome moth appearing in July.

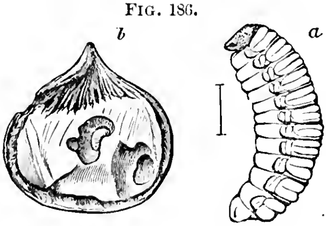
Many pretty and curious moths pass their preparatory stages of existence on the oak, and it is the food plant of the American silk worm (Fig. 185). The acorn is infested by the grub of a long-snouted weevil, like that which infests the chestnut (Fig. 186). Riley finds that in the Western States this grub so infests the acorns or mast as to diminish seriously the crop which is largely fed to swine.

To show the economy of nature and her care not to waste

material, we may refer to the case of the tiny acorn moth, which Mr. Riley tells us takes up its abode in the deserted, worm-eaten acorn, feeding upon the crumbs left by the young weevil. The caterpillar "secures itself against intruders by closing with a strong covering of silk the hole which its predecessor had made in its egress."

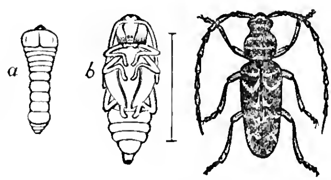
The locust tree has, among a dozen or more insects known to prey upon it, been nearly exterminated by the well-known "borer." The beetle (Fig. 187, *Clytus robiniæ; a*, larva; *b*, pupa) is known by its bright yellow trappings, and the yellow W on the base of its wing-covers. It is very abundant on the flowers of the golden rod in September. The beetle lays its eggs on the bark and the young borer

FIG. 186.



Chestnut Weevil.

FIG. 187.



Locust Tree Borer.

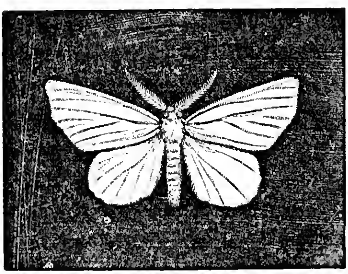
makes its way under the bark upwards into the wood, ejecting the chips and castings through an orifice in the bark. Eternal vigilance should be the watchword in dealing with the locust borer. Its presence may always be known by the little pile of dust at its door, and a wire thrust up its burrow will destroy the worm. It would be an excellent plan to have a growth of golden rods near the locust grove. These will toll the beetles in great numbers, when they can be plucked off and destroyed. In the middle states the locust, which there thrives better than in the north, is often defoliated by a leaf-mining beetle, a kind of Hispa.

But the pride of our lawns and roadsides is the elm. This tree we regard with a special reverence. Not so the

insects, for they war upon it with a savage disregard of the proprieties of life. The plant lice infest it by millions, puncturing the leaves with their tiny beaks, curling them up and transforming the originally beautiful foliage into an unpleasing mass of crumpled leaves, alive with moving parasites. Then comes the squads of canker worms, which speedily convert the umbrageous tops into a naked mass of limbs, the ghosts of their former selves. While this work is going on, and the tree, deprived of its lungs the leaves, is, as it were, at its last gasp, industrious borers of different patterns are laying out their streets tunnelled beneath the bark, like sappers and miners, preparing for the destruction of the entire fabric.

The canker worm infests the elm, and sometimes injures it as much as the apple. We have already studied its habits and will turn to another geometrid caterpillar, which so far as regards its destructive habits replaces in New York and Philadelphia the canker worm of Boston. It is wide-spread, however, over the country. I have found it in the wilds of northern Maine, but it is only known to me to abound in excessive numbers in the cities just mentioned.

FIG. 188.



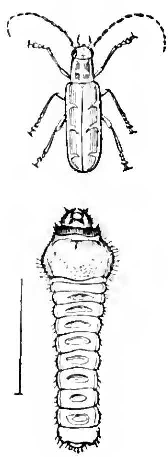
The Snowy Angle-wing.

The caterpillar, though confounded with the canker worm, is quite different in its physiognomy, having a large red head, while the body is wood colored, but red again at the end. The moth (Fig. 188), which may be called the snowy angle-wing, in allusion to the snow-white angular wings, flies about in the woods in July and August, when it lays its eggs. In the city of New York the caterpillars hatch as soon as the leaves unfold in the spring, and for a week or

two they live unobserved among the topmost shoots, and are not usually detected until half grown. Towards the end of June they descend to the ground and transform to chrysalides, and in about a week after the moth appears.

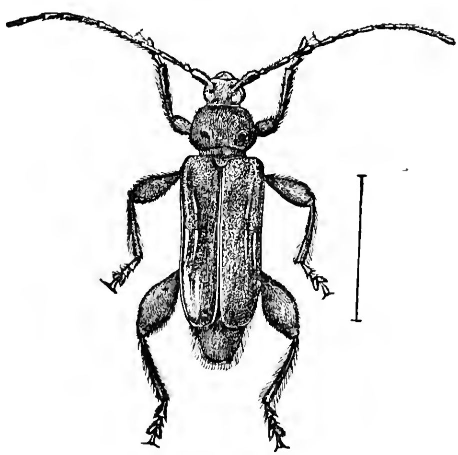
The most formidable borer of the elm tree is the three-toothed Compsidea (Fig. 189, beetle and larva). It consumes the inner bark and sometimes girdles the tree so as to suddenly kill it. The female lays her eggs in June on the trunk of the tree. The worms attain maturity in the

FIG. 189.



Elm Tree Borer.

FIG. 190.



Short lined Elm Borer.

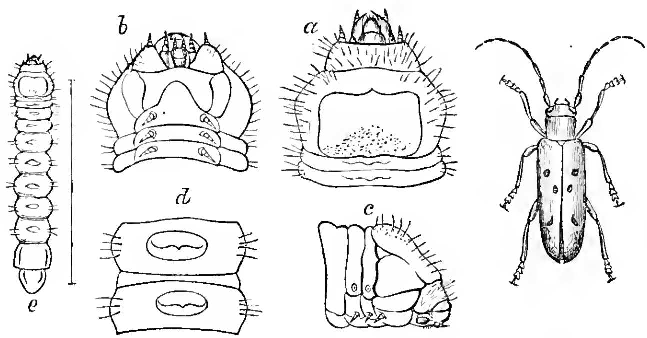
autumn of the third year succeeding, when they may be found under the bark. Another elm tree borer, but not as yet known to be at all common, is the short lined Physocnemum (Fig. 190).

Closely allied to the elm tree borer is the linden tree borer (Fig. 191, *Saperda vestita*, with its larva; *a*, *b*, *c*, different views of the head; *d*, body segments, enlarged). It perforates the linden tree, while the poplar is infested by

another species (Fig. 192, *Saperda calcarata; b*, upper and *c*, under side of the head, enlarged), one of our finest long-horned beetles.

Among other beetles found on the leaves of the elm are the European Calmar leaf beetle (*Galeruca calmariensis*). It is about the size of the common striped squash beetle, but grayish yellow, with three black spots on the thorax and a broad black stripe on the outer edge of the wing covers, with a small oblong spot near their base. Then there is the common Prussian blue flea beetle (*Haltica chalybea*, Fig.

FIG. 191.



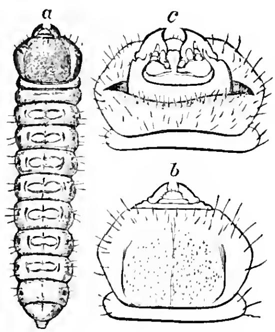
Linden Tree Borer and Beetle.

193), often occurring in great numbers on the leaves, and the Cotalpa beetle (see Fig. 21), which sometimes steals a few leaves.

The maples are unusually free from noxious insects. Young saplings are sometimes cut down in their prime by certain Buprestid borers, and the trunks are often riddled with the large holes made by the Tremex or horn-tail. This fine saw-fly may be found in maples, as well as elms and other trees, in all stages of growth in the autumn, the large, soft, white, fully grown larvæ, whose bodies terminate in a horny hook, occurring with the pupæ and the flies them-

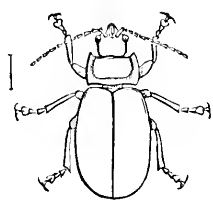
selves, which are found from July until October. It is probable that some of the flies may hibernate in their holes, as they were found in the tree as late as October. By means of her enormous saw or ovipositor, which she drives to the depth of half an inch through the bark into the wood, the female effects a safe lodgment for her eggs. They are apt to be social, and one may often see large numbers of them around a favorite tree, riddled with their holes, in some place previously wounded and deprived of the bark. Maples are

FIG. 192.



Poplar Tree Borer.

FIG. 193.



Flea Beetle.

sometimes killed by a beautiful Ægerian moth, which bores into the living trees.

Several of our most common and beautiful moths, as caterpillars, prey on the maples, from the minute Tineids up to the large rubicund Dryocampa and the Io moth (Figs. 64, 65). The leaves are sometimes mined by minute moths allied to our clothes moths. These little caterpillars are often flattened and in other ways curiously adapted for their life between the thin walls of their abode. The number of these mining moths is exceedingly great, and if any one could be found to devote his leisure to rearing them, and observing with care (note book in hand) their habits, he would confer a benefit to science. Nowhere more than

in these small neglected forms do we want a large number of observers. It would be an admirable subject of study for ladies, as the leaves containing them can be easily gathered, and if laid on wet sand in airy boxes or jars, the moths can be bred with much less trouble than the larger species.*

The walnut and hickory entertain a larger host of insect pests than any other deciduous tree; some seventy species are already known to draw their supply of food from these noble trees. Our black walnut wood comes from the western states, particularly Indiana, where the tree grows in the greatest perfection. It is estimated that within so short a period as ten years from the present date, the supply of black walnut lumber will be materially diminished. It is even now time to be planting groves of these precious trees in the western states. When they are in course of cultivation we can, in the imagination, if a scientist may be allowed to use that potent weapon, see the entomological evils which will cluster about those groves: a hundred different sorts of insects, represented by thousands of individuals, laboring away at root, branch, leaf, bud and fruit, unwittingly destroying the sapling, while securing their own means of livelihood.

Not to bore the reader with dry accounts of the beetles which occur in the walnut, we would allude to the tigrine Goës, which does the most serious damage to the trunks, as it bores large holes in the solid wood, lengthwise to the tree. The grub is rather large, cream-colored, with the head and the segment next to it yellowish. The beetle is a longicorn — we are now pretty familiar with the appearance of these longicorns with their remarkably long antennæ — and is brown, covered with a dense tawny pubescence, with a broad dark band beyond the middle of the wing covers, and

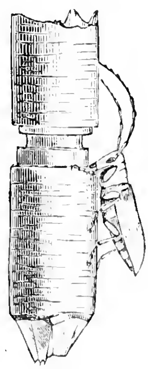
*Full directions for rearing caterpillars may be found in "Directions for collecting and preserving Insects," prepared for the use of the Smithsonian Institution by the writer.

another at their base. It is an inch in length, and is a common inhabitant of the hickory and walnut.

The locust tree borer also infests the hickory, and it is a curious fact that while the individuals which live in the locust tree appear as beetles in September, those which come from the hickory, though not differing specifically, appear in June, three months earlier.

The hickory girdler (*Oncideres cingulatus*,* Fig. 194) partially repeats in its singular habits those of the oak pruner. I will not attempt to condense Professor Haldeman's account of this insect, simply begging to differ from the writer's belief that the habit, unusual as it is, could never have been acquired. Until we know more of the habits of these Oncideres, and there are a number of other species of this and closely allied beetles in Central and South America, we are hardly in a position to deny but that there may be other species with quite similar habits, which in their turn may be related to still other forms which may exhibit traits intermediate between the girdler and the average longicorn beetle. It is only by comparing the intellectual acts of a long series of closely allied species that we shall be able to ascertain what is exceptional, and possibly be able to get a glimpse at the origin of such exceptional habits. It is for this reason that the study of the habits of our common, noxious insects will have a double value, an economic one and a philosophical one. They are so numerous that we can never be at a loss for material on which to make our observations and experiments.

FIG. 194.



The Girdler.

"In our walks through the forests our attention was fre-

* By a mistake, owing to the slipping of the bark after drying from each side of the notch, the incision is wrongly represented; the cut should be represented as somewhat square in outline.

quently drawn to the branches and main shoots of young hickory trees (*Carya alba*), which were girdled with a deep notch, in such a manner as to induce an observer to believe that the object in view was to kill the branch beyond the notch, and extraordinary as it may appear, this is actually the fact, and the operator is an insect whose instinct was implanted by the Almighty power who created it, and under such circumstances that it could never have been acquired as a habit. The effect of girdling is unknown to the insect, whose life is too short to foresee the necessities of its progeny during the succeeding season."

"This insect may be seen in Pennsylvania during the two last weeks in August and the first week in September, feeding upon the bark of the tender branches of the young hickories. Both sexes are rather rare, particularly the male, which is rather smaller than the female, but with longer antennæ. The female makes perforations in the branches of the tree upon which she lives (which are from half an inch to less than a quarter of an inch thick), in which she deposits her eggs; she then proceeds to gnaw a groove of about a tenth of an inch wide and deep around the branch, and below the place where the eggs are deposited, so that the exterior portion dies, and the larva feeds upon the dead wood and food which is essential to many insects, although but few have the means of providing it for themselves or their progeny by an instinct so remarkable."

"Where this insect is abundant, it must cause much damage to young forests of hop-holes by the destruction of the principal shoot."

A wood engraver plies its trade of scoring the trees beneath the bark. This is the *Scolytus caryæ*, whose habits have been well described by Mr. Riley. In Illinois, during a period of about ten years, it destroyed "many hundreds of fine young trees." Mr. Bryant writes that "it has sadly thinned my beautiful grove, and bids fair to destroy all the

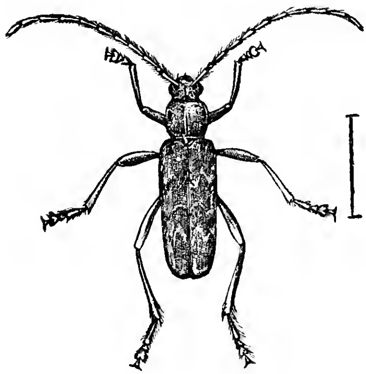
hickory trees in it." Mr. Riley adds, "the beetles issue the latter part of June and fore part of July. Both sexes bore into the tree, the male for food and the female mostly for the purpose of laying her eggs. In thus entering the tree, they bore slantingly and upward, and do not confine themselves to the trunk, but penetrate the small branches and even the twigs. The entrance to the twig is usually made at the axil of a bud or leaf, and the channel often causes the leaf to wither and drop, or the twig to die or break off.

"The female in depositing confines herself to the trunk or larger limbs, placing her eggs each side of a vertical chamber, as described by Mr. Bryant. Here she frequently dies, and her remains may be found long after her progeny have commenced working. The larvæ bore their cylindrical channels, at first, transversely and diverging, but afterward lengthwise along the bark, always crowding the widening burrows with their powdery excrement, which is of the same color as the bark. The full-grown larva is soft, yellowish, and without trace of legs. The head is slightly darker, with brown jaws, and the stigmata so pale that they are with difficulty discerned. It remains torpid in the winter, and transforms to the pupa state about the end of the following May. The pupa is smooth and unarmed, and shows no sexual differences. The perfect beetle issues through a hole made direct from the sap-wood, and a badly infested tree looks as though it had been peppered with No. 8 shot. The sexes differ widely from each other, the male having spines on the truncated portion of the abdomen, not possessed by the female. The eggs are deposited during the months of August and September, and the transformations are effected within one year, as no larvæ will be found remaining in the tree the latter part of July."

The chestnut tree is sometimes infested by the Shining Arrhopalus (Fig. 195). Except the fact that it has been taken from the chestnut tree, I know nothing further con-

cerning its habits, nor of the appearance of its grub. The beetle itself is blackish brown, with slight, dark blue reflections. The top of the head and the sides of the prothorax

FIG. 195.



The Shining Arrhopalus.

and under side of the body are covered with short, fine gray hairs, and there are silvery w-like markings on the wing-covers.

We have thus seen what a force in the world these beetles are. Their work is done slowly but effectively, and their gnawing teeth, though slow in action, are as resistless as the "mordant tooth of time." Beetles have in fact well earned the right to have engraved on the escutcheon of their order the old saying: *Scarabæus aquilam quærit.*

10. Insects as Mimics.

MAN, especially in his savage state, is as a rule obliged to resort to various subterfuges to provide himself with animal food. The hunter tracks his quarry through the woods, his dress of hides, or his naked skin harmonizing with the dusky hues of the forest; his step is wary and light, his weapons are noiseless, the deer falling dead from his arrow, the bird from his blow gun without startling their fellows; or he hunts them by traps, from behind screens or while hidden by the foliage of trees. At times he disguises himself, and stalks the deer dressed in the head and skin of one of their own kind. He mimics their voices, calling the moose by means of a birch bark horn, and whistling to the woodcock or snipe.

The civilized sportsman, if he would be successful in the chase, adapts his hunting suit to the colors of the field or woodland, wearing gray or green, some color harmonizing with the landscape through which he ranges. Even his pointers or setters are protected by their tan-brown hue. He makes decoy ducks, and tolls in a flock of ducks or geese flying overhead or feeding off-shore beyond the reach of his gun. The fact that birds and quadrupeds are so easily deceived is a good proof that the use of disguises among animals in a state of nature is an actual fact. If some birds can be deceived by clumsy, painted, wooden decoys, others may mistake a caterpillar for a twig, a weevil for a bud, or an edible butterfly mimicking one which they generally discard as too nauseous to their taste.

All this mimicry on the part of man is conscious. What is often necessary with man is still more essential with animals. In the animal world there is an unconscious mim-

icry. The manifold disguises are worn unwittingly by the brute, the bird, or insect or mollusk, but there is no less an underlying design in nature, and some useful end subserved. That everything which exists has some use in the world may be regarded as an axiom. The savage knows that himself and his offspring will starve unless he by strategem and through some disguise can kill his game. Unless the insect protects itself from harm by imitating some natural object, or other insect which enjoys immunity from the enemies peculiar to the mimic, it and its species will die out. All the disguises in nature are, then, for a manifest utilitarian purpose, and we shall see that each species is by some peculiarity in its form, or color, or movements, at one or another critical period in its life, protected and preserved in the struggle for existence. It often happens that the weaker species are overlooked by their enemies, while on the other hand the predaceous species are as often enabled to approach their prey through the disguise they have assumed.

But it will be seen that the ultimate fact in this matter of mimicry is, as insisted on by Messrs. Darwin and Wallace, the advantage to the species. It will not unlikely occur to the unbiassed reader that the result of this law of mimicry is rather *the preservation of forms already established*, than the origin of new ones.

I shall assume as true that quadrupeds, birds, and insects, and the lower animals as well, are deceived and protected in turn by the disguises they assume, and that the end is a utilitarian one; while I disagree with the conclusions of those who believe that species originate from mimicry, assuming that if some species owe their preservation to this cause, they may have originated from the same natural causes as their unsuccessful fellows whom mimicry, or rather the want of it, failed to preserve. The fossiliferous strata of our globe are filled with the remains of organisms which have perished in unsuccessful attempts to survive in the

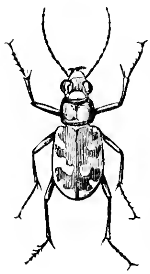
struggle for life in a world existing in a state of constant inequilibrium. It is the changes in the conditions of life, the revolutions in the physical surroundings of organisms, which have induced the transformation of one species into another, while protective mimicry has often acted as a conservative agency in preserving the species. Both sets of causes have, then, been factors in the origination of animals and plants as we see them, and Darwinism is perhaps as essential as Lamarckianism in explaining the present conditions of life on the globe.

But to come at once to the subject of protective mimicry, we will study in the first place:—

Insects mimicking other natural objects.—The examples under this head illustrate some of those harmonies in nature which the distinguished Bernard de Saint Pierre saw so clearly. The adaptive coloration of animals, the harmony in tint and form with the trees on which they live, or the rocks among or under which they hide, the sand over which they run, are a part of the general harmony in nature. A desert animal is of a sandy complexion, a silk-worm moth is brown, a grasshopper is dusky for much the same reason that the grass is green, the sky seems blue, or the rocks are gray. These harmonies in form, in color, are as striking in the world as a whole, as in isolated portions of it, or isolated species of the animals or plants growing on its surface. These harmonies extend to other worlds and systems of worlds, and are cosmical in their nature. So the causes that lead to the origination of life, of a new species, are perhaps of a piece with those resulting in the origin of a planet. We must remember that life at first resulted in all probability through the action of cosmical laws. Before animals and plants had multiplied to any extent, where was the material for the laws of natural selection to act upon? There was once a time when some of the mills of the gods failed to run for the reason that there was nothing to grind.

Among the insects adapted by their peculiar style of coloration to live on the sand or soil are the tiger beetles. They are most commonly seen running over sands by the river or on the warm, light colored soil of wood or forest paths. The *Cicindela generosa* (Fig. 196) is ornamented more conspicuously than usual with broad light bands and spots. It is found on the white sands of Cape Cod and the beaches southward. But a more decided case of protective mimicry is the white-backed tiger beetle (*Cicindela dorsalis*). Here the wing-covers and front of the head (clypeus) are white, while the back part of the head and the prothorax are dark, so that as the beetle lies on the white sand in wait for its prey, it would be easily mistaken for a hole or dark spot or pebble. On the other hand the bright green six-spotted Cicindela (*C. sex-guttata*) is adapted for its life in the grass in which it runs and flies, and in its flight would be mistaken by its enemies or victims for a large green fly (*Musca vomitoria*).

FIG. 196.



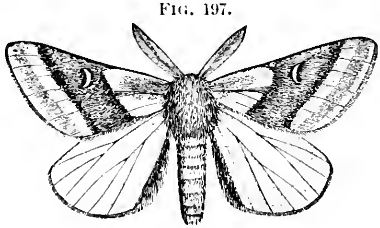
Tiger Beetle.

"The beautiful *Cicindela gloriosa*, of a very deep velvety green color, was only taken upon wet mossy stones in the bed of a mountain stream, where it was with the greatest difficulty detected. A large brown species (*C. heros*) was found chiefly on dead leaves on forest paths; and one which was never seen except on the wet mud of salt marshes was of a glossy olive so exactly the color of the mud as only to be distinguished when the sun shone, by its shadow! Where the sandy beach was coralline and nearly white, I found a very pale Cicindela; wherever it was volcanic and black, a dark species of the same genus was sure to be met with." (Wallace.)

The black or reddish ants are protected from observation by their dark colors in climbing the trunks of trees, while

the smaller, lighter species frequent the sandy light paths about our dwellings. Within doors the Reduvius (Figs. 56, 57) covers itself with dust, a good disguise in approaching its prey and escaping its enemies. Ground spiders by their hues simulate the inequalities of the dark soil over which they run. The trap door spiders (Mygale, Fig. 62) are colored like the soil in which they excavate their nests. The desert Mantis (Eremophila) is of a sandy hue, and is easily confounded with the sands of the Sahara. An example of protective coloration is probably afforded by a moth of the silk worm family (*Euleucophæus tricolor*, Fig. 197), which inhabits New Mexico. Instead of the dark brown hues of its allies, it has a faded appearance, adapting it for conceal-

FIG. 197.



Euleucophæus.

ment while resting on the dry parched ground. It will be interesting to learn whether its exceptional style of coloration adapts it for a life in the deserts of New Mexico. Here the change is evidently induced by the dry climate.

The grasshoppers nearly always harmonize in color with the general hue of the fields in which they abound. They are most abundant towards the last of summer, when the fields have lost their freshness and the grass has turned brown; at this time the russet garb of the Carolinian locust, and the red-legged grasshopper admirably conceal them when at rest. I have noticed the sulphur-winged grasshopper (*Arphia sulphurea*) flying about dry hillsides, and in northern Maine, the crackling grasshopper (*Trimerotropis*

verruculata) is especially abundant on burnt lands and elevated hill tops or in mountain valleys, where it harmonizes well with the soil. The maritime grasshopper (*Trimerotropis maritima*) is, like the maritime tiger beetle, specially adapted for concealment on the sea shore, as observed by Mr. Scudder, who says "it so closely resembles the color of the sand on a sea beach that it is difficult to see it when alighted." It differs remarkably from its inland allies by the white or pale bands and spots.

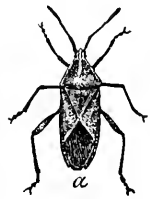
How protective mimicry may affect the different species of a genus is shown in the common red-legged grasshoppers. The *spretus* of the west, and the *femur-rubrum* of the east, harmonize in color with the brown hues of the grass lands in August and September, but the large two-banded one (*Caloptenus bivittatus*), so abundant during the same months in our gardens, in its green coat with yellow stripes, agrees with the green and yellow tints of our garden vegetables, among the leaves of which it lives. From its comparatively sedentary habits it grows larger and much more clumsy than its lean and agile congeners.

There are numberless little froth or spittle insects, such as the green *Helochara communis* and the russet *Ptyelus lineatus*, our commonest spittle insect, which pass their youth in concealment in masses of froth on the stems of grass in June. These masses of bubbles would be easily mistaken for drops of dew, or at least not suspected of containing any living beings. The bright pea-green leaf hopper abounds late in summer with others of its ilk in the highly colored grasses of damp places, which retain their freshness late in the autumn. On the other hand, the Ptyelus in its brown dress harmonizes with the hues of the upland fields which have turned brown by the summer droughts. Many other hemipterous insects, however gayly colored after they fly about, in their early wingless stages are green, like the herbage in which they hide. The common squash bug (Fig.

198) is of the exact color of the garden soil; it is only seen about the roots of the plant near the ground, while the little yellow beetle (Fig. 199) is a frequent visitor of the yellow flowers.

Among the moths which hide on the surface of the ground or in the grass are the numerous species of owlet moths (Noctuidæ). The Agrotis and Mamestra, and many others of this family, as caterpillars, show many peculiar adaptations in color to the soil on which they live. The dusky, livid cut worms would be easily overlooked as they crawl over the soil, when disturbed from their retreats under sticks and stones. They move about at night, and nocturnal insects are usually dull colored. On the other hand the pretty, green, cinnamon spotted Leptosia (*L. concinnimacula*) flies by day in the short grass. When the larger, dull brown moths, such as that of the army worm of the north, are disturbed, they quickly dart into the dry rusty stubble, and it is almost impossible to detect them if they remain quiet, as they often have the instinct to do when an enemy is close at hand.

FIG. 198.



Squash Bug.

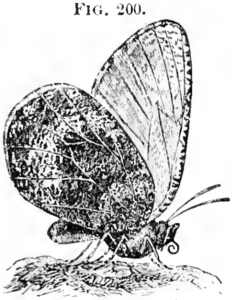
Lichen-covered rocks are frequented by certain moths and butterflies which afford some of the most remarkable examples of protective coloring I have ever observed. This is particularly noticeable in Arctic and Alpine Lepidoptera. The cranberry fields and barren moors of Labrador abound in little gray and dun colored leaf-rolling moths, which are impossible to detect until they are startled. Some geometrid moths are called carpet moths in England from the large number observed carpeting the lichen and moss-grown rocks of the hills of Scotland. I have captured within an hour's time as many as seventy-five of the Polar Glaucopteryx on Table Rock at the mouth of the Straits of Belle Isle. As they rested on the lichened rocks it was

FIG. 199.

Squash Beetle.

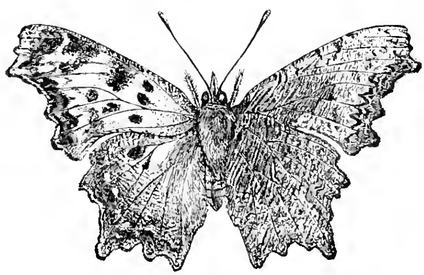
extremely difficult to detect them, so well did their pepper-and-salt and greenish hues agree with the gray and green rocks. On another occasion, while entomologizing on some peculiar, light gneiss rocks overgrown with gray lichens, a couple of hundred miles farther north on the Labrador coast, I found it impossible to detect the Anartas, though resting almost under my feet, so closely did these owlet moths resemble the rocks over which I clambered. Again, on the hills above the Moravian settlement of Hopedale, thousands of the beautiful dun-tinted Chionobas of different species fluttered feebly over the lichen-clad rocks, the underside of their wings corresponding exactly in color with the ground

FIG. 200.



Chionobas semidia.

FIG. 201.



Grapta progne.

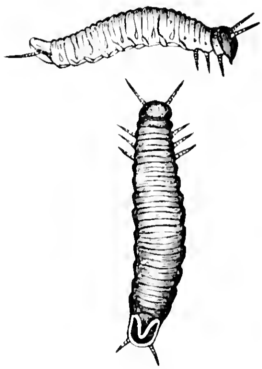
on which they rested. This scene is repeated on that bit of Arctic landscape, the extreme summit of Mt. Washington, where the *Chionobas semidia* (Fig. 200, from Tenney's Zoology) occurs; as well as in other Alpine peaks of Europe and the Rocky Mountains. A geometrid moth (*Marmopteryx strigularia*), which inhabits the mountainous regions of the eastern states from Vermont to West Virginia, has the same peculiar marbled under surface of the hind wings, and also an allied species found in the Sierra Nevada.

The under side of the Grapta butterflies (Fig. 201, *Grapta progne*, right side) have the color of dead leaves, and as they sit in paths with their wings folded over their backs would

be readily mistaken for a dead leaf. All these Graptas, with *Vanessa Antiopa*, are among the most abundant of our butterflies. The most perfect resemblance to a leaf with its stalk is afforded by the well known case of the Kallima, figured and described by Mr. Wallace in his interesting book entitled "The Malay Archipelago."

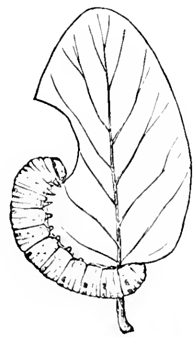
The caterpillars which feed on herbage or the leaves of trees are almost universally protected from the attacks of birds by their adaptive coloration. Those caterpillars which feed on the pines have a family look, though belonging to

FIG. 202.



Pine Lyda.

FIG. 203.

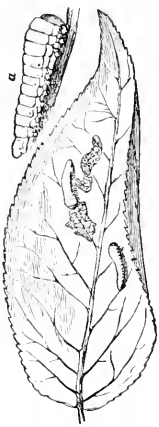


Honeysuckle Abia.

different natural families. For example, the larva of the European pine Fidonia, our native Cleora of the pine, the pine Trachea, the pine hawk moth (Ellema) and other caterpillars have markings very much in common, having as a ground color the peculiar green of fresh pine needles, with red stripes and bars corresponding in tone to the red sheaths of the needles. The leaves of the Austrian pine are devoured by a saw fly larva (Lyda, Fig. 202) which is reddish olive green with reddish and purple patches and lines. The Abia of the Tartarean honeysuckle (Fig. 203) is of a peculiar

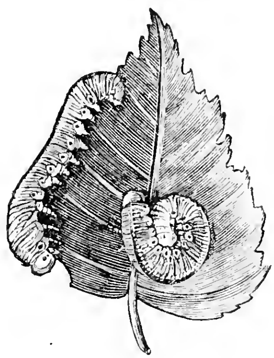
pale bluish green color, somewhat resembling the peculiar glaucous green hue of the leaf on which it feeds. It is generally overlooked until the bushes are stripped. This worm does not seem to be eaten by birds, probably on account of the fluid which is suddenly poured out through the pores in the sides of the body when it is disturbed. The false caterpillar of the currant saw fly is rarely eaten by birds and enjoys an unusual immunity; so also the pear slug (Fig. 204) perhaps if not on account of its resemblance to a slug (for slugs are greedily devoured by birds), possibly on

FIG. 204.



Pear Slug.

FIG. 205.



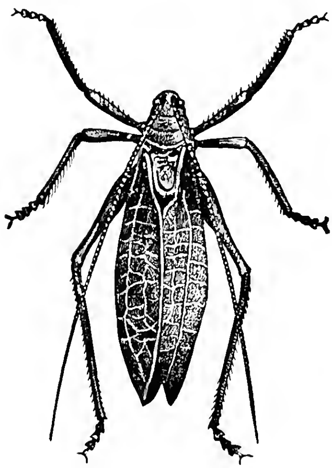
Cimbex Larva.

account of some disagreeable taste. The larva of the Cimbex (Fig. 205) when coiled upon a leaf has a tolerable likeness to the common *Helix albolabris*.

Returning again to the grasshoppers, the species of the family of Locustarians, to which the Katydid belongs, are modified for a life hidden among the leaves of trees. Nearly all the species are green. In their youth they hop about in the grass, and are better protected from harm than the young Acrydians, which are usually dark, though some are green.

Some species remain in the grass throughout their lives, but most of the Katydids and others which produce a loud cry reside in the trees. Here it is difficult to detect them, their green hues matching so well the hues of the leaves forming their covert. Moreover the fore wings are inclined to be broad and oval, as seen in those of the Katydid (Fig. 206). It will be noticed in this insect how closely the veins resemble those of the leaves. There are, in the Museum of the Peabody Academy of Science, a number of Brazilian species

FIG. 206.



Katydid.

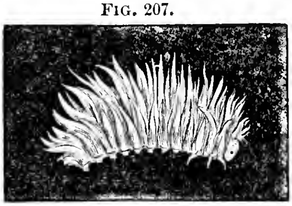
allied to the Katydid which have very broad, thick fore wings, some oval in shape like orange or lemon leaves, others with jagged outlines, somewhat as in the holly leaf. Others are of the color of a dead leaf. Such is the *Cyrtophyllus perspicillatus*, which bears a close resemblance to a withered leaf. There is in Brazil a grasshopper of this family, which represents the East Indian Megalodon figured by Wallace on page 580 of "The Malay Archipelago."

There are some insects which resemble anything but them-

selves. This paradox may be explained by a glance at a Selandria larva (Fig. 207) which sometimes occurs on the chestnut. Its body is entirely concealed by a cottony secretion which rises half an inch above the body. A group of these sluggish caterpillars could feed exposed on a leaf with impunity. The bark lice, such as Eriosoma, cover themselves with a cottony exudation which serves as a disguise. Many bright colored flower beetles are protected by their resemblance to the tints of the flowers in which they hide. The Galeruca and Clytus, almost invariably found on the golden rod in September, are thus protected.

Why butterflies are so much more commonly seen than their caterpillars is not known. It is probably due to the fact that the latter are often of the color of the leaves on which they feed. The caterpillar of the *Colias Philodice*, our common sulphur yellow butterfly, which lives on clover, is rarely found, owing to its pea-green tint so much like that of the clover leaf on which it feeds. It is possible that the caterpillar is so well protected that the butterflies can afford to have their numbers thinned out by predaceous insects and birds. So with the caterpillars of the white cabbage butterflies, whose dark green velvety coats so thoroughly assimilate them with cabbage or turnip leaves or stalks. The caterpillar of *Vanessa Antiopa* is one of the most conspicuous objects in nature, large clusters of these black spiny creatures feeding exposed on the leaves of the willow and other plants. It is probable, however, that bristling as they are with spines, birds do not fancy them; but the butterflies as well as the chrysalides assume the tints of dead leaves and old wood, and the butterfly may be easily confounded with the trunks of the trees on which it rests, as it does not settle on the ground as in

FIG. 207.



Selandria Larva.

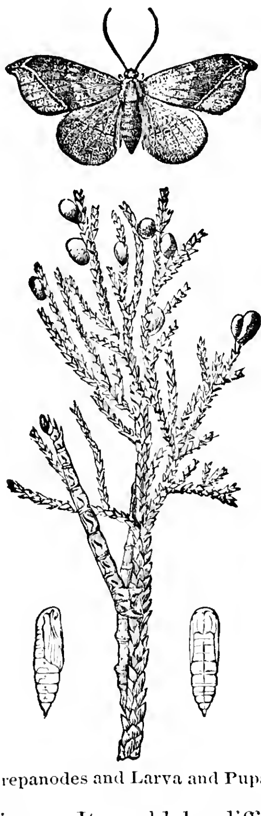
the Graptas. Many geometrid moths rest on the bark of trees, where they escape the observation of the entomologist whose eye is trained at looking for them, and perhaps also of the birds. The white pine trees often shelter the *Tephrosia Canadaria*, which I have found in no other position. The Red Under wings, or Catocalas, spend their days on the bark of deciduous trees, and only expose themselves to the attack of birds when they show their gorgeous red and yellow hues in flight.

The Arctian moths, so brightly painted with strong contrasts of black and vermilion or red, can afford to be snapped up by the birds, which allow their spiny, hairy larvæ to go scotfree. It is possible that the bright colors of the Arctians and other Bombycidæ, as well as the butterflies, are needed to ensure the meeting of the sexes, as by their bright colors they can detect each other afar off; though the acute sense of smell possessed by these moths, whose antennæ are broadly pectinated, may be sufficient for ensuring the prompt recognition of each other's presence. That the white colors of the *Spilosoma Virginica* and the moth of the fall web worm (*Hyphantria textor*) serve the same purpose of mutual recognition as the conspicuous white Pieris, seems probable. Mr. Darwin (Descent of Man, i, 387; Appleton's edition, 1871) states that "the common white butterfly, as I hear from Mr. Doubleday, often flies down to a bit of paper on the ground, no doubt mistaking it for one of its own species." The owlet and geometrid moths fly in such large numbers that there is a greater chance of their encountering one another in the night, particularly as they feed on common objects of attraction, *i. e.*, the honey of flowers.

But all these points need to be thoroughly investigated. Many statements and assertions on the subject of mimicry need reëxamination and confirmation, and some of the facts I give here are simply hints for future observation and experiment.

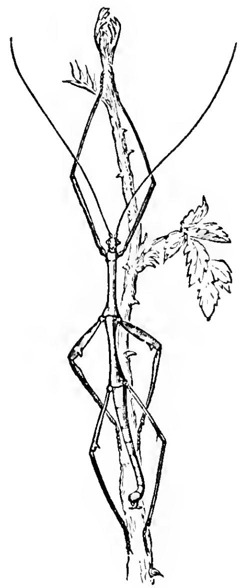
The most wonderful cases of protective mimicry among caterpillars are afforded by the geometrids or span-worms. I have never seen a better example than that afforded by the larva of *Drepanodes varus* (Fig. 208), which feeds on the

FIG. 208.



Drepanodes and Larva and Pupa.

FIG. 209.



Stick Insect.

juniper. It would be difficult in the accompanying figure, as well as in life, to tell where the caterpillar begins or the juniper twig ends. The body of the larva holds itself out stiff and rigid, after the manner of its tribe, with warts over

its back exactly like the leaf scars of the juniper, and the entire worm concolorous throughout with the bark is a perfect imitation of the twig.

Nearly every bush has its distinct kind of inch worm or geometer, which resembles a broken branch or twig when it is at rest and holds itself out stiff by its muscular hind legs. Most caterpillars remain quiet by day, when they need protection, and feed at night. The stick insect (Fig. 209, from Tenney's Zoology) is so obviously a mimetic form that we need only speculate how it came to differ from its allied forms, unless the intermediate forms have become extinct through the want of similar adaptation. This and the celebrated leaf-insect are the two insects which first come to mind when the subject of mimicry is mentioned. The Phyllium is broad and flat, with leaf-like dilatations on the legs, while the broad wings are provided with a midrib and vein exactly like a dried leaf.

Other remarkable stick insects of the group of Phasmids are figured by Professor Westwood in his "Thesaurus Entomologicus Oxoniensis." Such as the *Extatosoma bufonium* from Australia, *Heteropteryx Castelnaudii* from Tringany, Malacca and *Ceroys laciniatus* from Nicaragua. They are much alike in form, though inhabiting different quarters of the globe, and are slender, with long legs, with flattened tubercles and spiny expansions, resembling the young and spiny twigs on which they possibly rest.

The caterpillars of the leaf-rolling and Tineid moths often live in rolled-up leaves, where they are protected in a great measure from their enemies; though the insectivorous birds, attracted perhaps by the deformation they cause in the foliage, feed upon them; and their insect parasites, particularly the minute chalcid flies, have the requisite instinct to find them out and oviposit in their bodies. No insects, however protected by these disguises, are ever thoroughly safe from the attacks of enemies espe-

cially created to gain their livelihood by preying upon them.

One of the most striking cases of mimicry is afforded by the caterpillar of the *Tolype Velleda*, as well as that of its ally, the lappet moth, which is found on apple trees, and would easily, when at rest, be mistaken for a swelling or cankered spot on the bark (Harris' Treatise on the Injurious Insects of Mass., 1862, p. 379). Miss Dix, as quoted by Harris on the same page, states that "when at rest the resemblance of its upper surface was so exact with the young bark of the branch on which it was fixed, that its presence might have escaped the most accurate investigation; and this deception was the more complete from the unusual shape of the caterpillar, which might be likened to the external third of a cylinder. The sides of the body were cloaked and fringed with hairs. It was of a pale sea-green color above, marked with ash, blended into white; and beneath of a brilliant orange, spotted with vivid black. When in motion its whole appearance was changed; it extended to the length of two inches, and two-thirds of an inch in breadth, its colors brightened, and a transverse opening was disclosed on the back, two-thirds of an inch from the head, of a most rich velvet-black color. It was sluggish and motionless during the day, and active only at night."

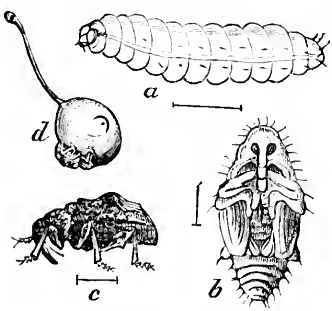
The gray color and roughened surface of many longicorn and Buprestid beetles which rest in the daytime on the bark of trees are undoubtedly protective, though why multitudes of these two groups of insects are, on the other hand, among the most highly colored and brilliant of any in existence, needs further investigation. Mr. Wallace observes that these brilliant beetles would not be eaten by birds on account of their very hard, dense tegument, but this will equally apply to the gray and dull colored species, which are evidently protected by these adaptive colors. The bright colored species are the exception in the temperate regions,

and more the rule in the hot and moist forests of the tropics. Here the physical environment of the animal is undoubtedly the primary cause of its high colors.

The buds of plants and trees are imitated by many kinds of weevils, whose oval, often rough, bodies and sluggish natures protect them. Such is the plum weevil (Fig. 210), which looks like a dried plum bud. The small cones of the pine are simulated by the *Chalcophora liberta*, a Buprestid beetle. Early in June when the brown Elaters are coming out of the ground and are found resting on the low maple bushes, I have observed some to resemble closely the long leaf buds of that tree.

Certain small weevils resemble the seeds of plants. Wal-

FIG. 210.



Plum Weevil and Larva.

FIG. 211.

Young Chlamy and case.

lace quotes Kirby and Spence's statement that the small weevil named *Onthophilus sulcatus* looks like the seed of an umbelliferous plant. Wallace also quotes Bates as saying that some tropical spiders "are exactly like flower buds, and take their station in the axils of leaves, where they remain motionless waiting for their prey."

Some beetles, like the little, thick, rounded, oblong Chlamys, have been noticed by Bates, and also by Wallace, to resemble the castings of large caterpillars, and the case of the larva of this beetle (Fig. 211), which is not uncom-

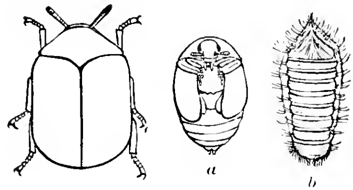
mon in the United States, is black and oval in shape, and would be readily mistaken for a pellet of bird's dung. Wallace quotes the statement of an observer, who had more than once mistaken an English moth, *Cilix compressa*, a little white and gray moth, "for a piece of bird's dung dropped upon a leaf, and *vice versa*, the dung for a moth." Wallace also tells us that "there are in the east small beetles of the family Buprestidæ, which generally rest on the midrib of a leaf, and the naturalist often hesitates before picking them off, so closely do they resemble pieces of bird's dung." The same might be said of the little dark brownish, bronzed Brachys often seen in midsummer resting motionless on the leaves of the oak.

Some carrion beetles are dark, like the decaying bodies under which they live, and so are their larvæ, but why other

FIG. 212.

Attagenus Larva.

FIG. 213.



Anthrenus and young.

forms, like the Necrophori and Necrophili, are banded so conspicuously with red or yellow, does not seem clear to us. Many of the small Catops, the Nitidulæ, the Staphylini, are dark red or brown or black, these colors harmonizing with the sombre tints of the decaying substances on which they live. I have noticed that the *Antherophagus ochraceus*, a dull ochreous reddish beetle, is of the same hue as the cells of the humble bee, in which they are often exceedingly common. The Dermestes, Attagenus (Fig. 212, larva) and

Anthrenus (Fig. 213; *b*, larva and *a*, pupa, all enlarged) assimilate in color the dried skins and decaying matter in which they luxuriate. The larvæ especially are so densely clothed with gray or reddish brown hairs, that it is difficult to detect them when at work in dried insects and bird skins. Their stealthy ways also favor their protection, and these beetles, like the weevils and many others, when disturbed feign death.

How this mimicry of death so common among insects came to be such a universal habit would form a curious subject of inquiry. It can scarcely, perhaps, be regarded as anything more than instinctive in the insects of the present day, but in the earlier ages of the world, when the insects were schooling themselves in the arts of life, such acts as these must have been in a degree conscious, and only became habitual after many mistakes and trials, resulting in the extinction of many individuals and incipient species. When one looks at the beds of fossil beings of the earlier geologic periods, he peers into the tombs of millions which could not adapt themselves to their constantly changing surroundings. No fossil being is known to us which could not have been as well adapted to its mode of life as the animals now living; but the conditions of life changed, and the species as such could not withstand the possible influx of new forms due to some geological change which induced emigration from adjoining territories, or to changes of the contour of the surface, with corresponding climatic alterations. Let one look at the geological map of North America before the Cretaceous period, ere the Rocky Mountains appeared above the sea, and reflect on the remarkable changes that took place to the northward; the disappearance of an Arctic continent, the replacement of a tropical climate in Greenland and Spitzbergen by Arctic cold. Are there not here changes enough in the physical aspects of our country to warrant such hypotheses of migrations with corresponding

extinctions and creations of new faunas out of preceding ones, as are indulged in by naturalists of the present day, in the light of the knowledge pouring in upon them from Arctic explorers and western geologists? Granted these extraordinary changes in the physical surroundings of the animals whose descendants people our land, do not a host of questions arise as to the result in the beings of our day of these changes in the modes of life, the modes of thought, so to speak, the formation of peculiar instincts arising from new exigencies of life, which have remodelled the whole psychology, as it were, of the animals of our country? Instincts vary with the varying structure and form of the animals. Change the surroundings, and at once the mode of life and psychology of the organism begin to undergo a revolution. These changes may result in the gradual extinction of whole assemblages of animals, which are as gradually replaced by new faunas.

Many, indeed most, insects are in our northern hemisphere represented in the colder months of the year by the chrysalis or eggs. These are eagerly sought after by the smaller birds, and are in most cases protected by their colors, or by their resemblance to the bark of the trees on which they may be laid. The eggs of the canker worm are gray, like the bark of the tree or paling on which they are deposited. The eggs of the tent caterpillar are covered over with a coating of gum, so that the bunch looks like an excrescence on the tree. The chrysalis of *Vanessa Antiopa* is exactly of the color of old wood, and it is often found hanging from fences and out-houses, while, before houses were built, for this butterfly belongs to an ancient family, it assimilated in hue the bark of trees. The cocoons of many of the silk moths, like those of the Promethea moth, are covered with leaves drawn around them in the process of weaving, and hang all winter on the wild cherry, having the semblance of a dead leaf. Those of the Polyphemus (Fig. 214) which fall

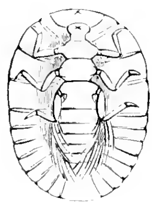
to the ground among the leaves of the oak are covered with dead leaves, and the color of the cocoon when bare harmonizes with that of the soil or leaves.

Aquatic insects are often nearly colorless, like the water they inhabit. Many water larvæ are pale green, like the plants in which they hide. What excellent mimics the caddis worms and Ranatra and Belostoma are, we have previously adverted to in the chapter on Insects of the Pond and Stream. To the cases there given might be added certain sluggish larvæ like Psephenus (Fig. 215) and others, which

FIG. 214.

Cocoon of the American Silk Worm.

FIG. 215.



Psephenus.

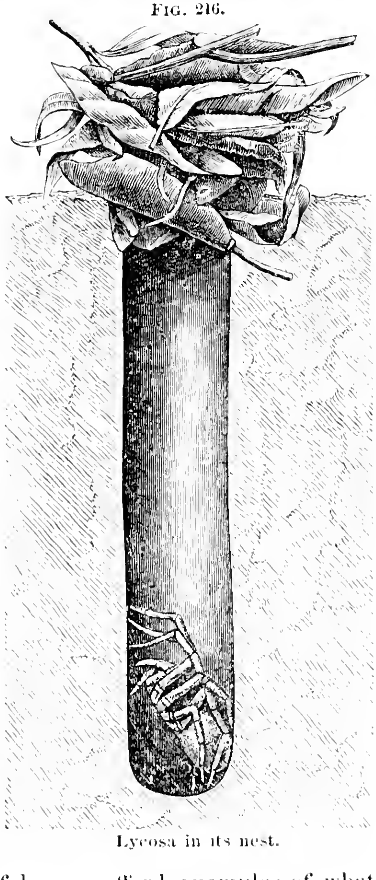
adhere to the under side of pebbles, and are thoroughly assimilated in color to the mud of streams and the shores of the sea.

Much light may be thrown upon this subject by a study of cave animals. Here the harmony in color and often in form to surrounding objects is most striking and the causes are quite apparent. The cave insects becoming blind from the darkness of their subterranean abode, lose their colors and are assimilated to the colors of the stalactites on which they walk or the walls of the cave to which they cling. The ground beetles, instead of being dark like their out-of-door relations, here fade out to the color of the limestone sands over which they run. The harmony in form and color with the environments of their subterranean abode is as apparent as the cause.

All the cases hitherto given are examples of unconscious mimicry, and in many, if not most, cases the effect of climatic and other physical causes, resulting in a general harmony of hue and form which adapts all animals to the world in which they live. But there are a few cases known in which it is difficult not to believe that at some time in the life of the species there was a conscious intention to deceive. I refer to the trap door spiders and other forms which curiously conceal the entrance to their holes with the manifest design of hiding it from their enemies or of using it as an ambuscade. I would refer the reader to Moggridge's capital work on "Harvesting Ants and Trap Door Spiders," for much curious and reliable information regarding the habits of these spiders. Like our trap door spider, Mygale (Fig. 62), its allies in southern Europe excavate deep tunnels in the earth; they seem to take unusual pains to conceal the entrance from their enemies. The hole is usually situated in moss and small ferns, etc. After the door is made the top is actually planted with bits of moss and small plants, so that it is often impossible for the practised eye to detect the trap door. Moggridge remarks that the moss thus transplanted by the spiders "grew as vigorously, and had in every way the same appearance, as that which was rooted in the surrounding earth, and so perfect was the deception that I found it impossible to detect the position of the closed trap even when holding it in my hand. There can be no doubt that many nests escape observation in this way, and the artifice is the more surprising because there is strong reason to believe that this beautiful door-garden is deliberately planted with moss by the spider, and not the effect of a mere chance growth." The evidence he adduces is strongly confirmatory of this view. In the nests of other spiders he tells us that "it is rare to find any of the larger mosses or lichens growing upon them; but, as if to compensate for this deficiency, a variety of foreign materials are

employed which are scarcely ever found in cork doors, such as dead leaves, bits of stick, roots, straw of grasses, etc., and I have seen freshly cut green leaves, apparently gathered for the purpose, spun into a door which had recently been constructed."

FIG. 216.



Lycosa in its nest.

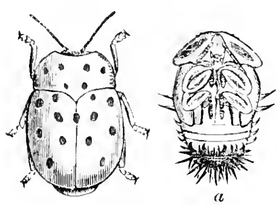
We have in this country a species of Tarantula (Lycosa) which as if by design covers its hole with a mass of dead and dry leaves, as indicated in Fig. 216 (after Emerton). In an article in the "American Naturalist," vol. iv, Mr. Emerton tells us that his attention was drawn to these nests by Mr. J. A. Lintner, who noticed on the sandy hills west of Albany, N. Y., a number of holes about half an inch in diameter, each surrounded by a ring of sticks and bits of leaves loosely fastened together by fine threads.

The larvæ of Cassida, the helmet beetle, and Lema, which live exposed to the sight of their enemies on the upper side of leaves, afford examples of what, at some period in the life of the species, may have been a conscious attempt at deception. The larva of Cassida is broad, flat and oval, edged with long, sharp spines. By

means of the two long terminal spines terminating its upturned extremity it holds the old cast skin over its body like an umbrella. The beetle itself in its resplendent golden hues has been compared, by Wallace, to "glittering dew-drops upon the leaves." In another form, *Chelymorpha cribraria* (Fig. 217 ; *a*, pupa), which is considerably larger than Cassida, and feeds very much exposed on the silk weed, and sometimes on the raspberry, is also protected by its cast skin, though in a less degree.

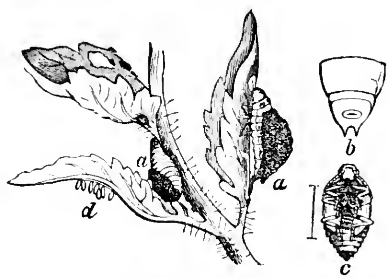
The larva of the common potato beetle of the eastern states (Fig. 218 ; *a*, larva ; *b*, *c*, pupa ; *d*, eggs) covers its dull gray soft body with a black mass of its excrement,

FIG. 217.



Helmet Beetle and Pupa.

FIG. 218.



Young Potato Beetle.

which is at once a protection from the heat of the sun and the attacks of birds, which probably regard them as anything but living and edible insects.

It would seem, then, that while in the generality of cases insects harmonize in color and often in form with surrounding objects, or even distinctly mimic natural objects, this is owing in all probability mainly to the physical environment of the animal ; in a few cases, however, there is an appearance of design, and natural selection has been the means by which the mimicry has been effected and the species preserved.

Mimicry of other Insects.—We now come to instances where insects resemble others of different genera, families and orders. They are exceedingly numerous, and entomologists have been familiar with some of them for at least a century. Struck with the fact that as a rule the insects which were mimicked were higher in the scale than the mimickers, the writer attempted in an essay published in 1863 * to classify some of the known facts, adding some supposed to be new, and to give a partial explanation of them. In the light of the facts published a year previous to this by Mr. Bates,† and afterwards by Mr. Wallace ‡ and Mr. Darwin, § I am inclined to the belief that the resemblance in pattern and color between insects belonging to different groups is probably due to causes more fundamental than natural and sexual selection, and reaching possibly farther back in geological time. I will quote the following passage from my essay:

"If we consider the Hymenoptera, Lepidoptera and Diptera by themselves, in the order in which Latreille has placed them, we shall find these three groups full of reciprocal analogies. Certain forms in the one suborder leap over their neighboring suborder to find their analogues in one a third removed; or again, we see analogous forms between the two higher groups, leaving the lowest for a while isolated; or on the other hand the two lower groups are thus united, leaving the highest one standing by itself. For example, the clear-winged Sesia imitates the humble-bee in its form and flight; the different species of Ægerians (Fig. 219, *Ægeria tipuli-*

* On Synthetic Types in Insects. Journal of the Boston Society of Natural History. 1863.

† H. W. Bates. Contributions to the Insect Fauna of the Amazon Valley. Lepidoptera: Heliconidæ. Transactions of the Linnæan Society, vol. 23, 1862.

‡ A. R. Wallace. Mimicry, and other Protective Resemblances among Animals. Westminster Review, July, 1867. Reprinted in "Contributions to the Theory of Natural Selection" 1870.

§ Charles Darwin. The Descent of Man, and Selection in Relation to Sex, 1871.

formis) simulate members of nearly every hymenopterous family, as we can see when recalling such names as *apiformis*, *vespiformis*, *philanthiformis*, *tiphiæformis*, *scoliæformis*, *spheciformis*, *chrysidiformis*, *cynipidiformis*, *formiciformis*, *ichneumoniformis*, *uroceriformis*, and *tenthrediniformis*. So also other Ægerians resemble different family forms of Diptera, as seen in the names *culiciformis*, *tipuliformis*, *bibioformis*, *anthraciformis*, *muscæformis*, etc. In the Diptera we find Bombylius, resembling, as its name implies, Bombus; and also Laphria, which so closely apes the humble-bee in its form, coloration, size and flight, even to the buzz, which is, if anything, still louder. Also, there is the strongest resemblance in some Syrphi to Vespa, and especially to different species of Crabro. But while the Lepidoptera and Diptera resemble the Hymenoptera, we cannot say that Hymenoptera ever *assume* the form of any flies and moths. They seem isolated, and resemble only themselves. In the case of the Laphria, the plump, bee-like form, and the dense yellow and black hirsuties, which cause them to be mistaken for humble-bees by persons unacquainted with their structural differences, are just those features that are exceptional in the Diptera, and are normal in the Hymenoptera. The fly to get them has to pass over one suborder to obtain a bizarre form which is a prevalent and common attribute of the Apidæ.

FIG. 219.

Ægeria.

"There is a similar parallelism of analogous forms between the Coleoptera, Hemiptera, Orthoptera, and Neuroptera, which seem bound together by affinities such as those that unite by themselves the bees, moths, and flies. Thus there are certain Hemiptera (Corixa) that resemble the coleopterous genus Brachys; Forficula is analogous to the Staphylinidæ and Blatta may be said to resemble some Lampyridæ. The close affinities between the Orthoptera and Neuroptera hardly admit of these analogous forms, though we find them

still. Here again we see the isolation of the Coleoptera from the other suborders with which it is connected. The suborders below it, by an exact parallel with the case above mentioned, reach up and connect themselves by these remarkable analogies with the Coleoptera, which do not in turn assume any of their forms. Some Orthoptera are very coleopterous-like, and some Hemiptera are very coleopterous-like. The reverse cannot be said. So the Diptera and Lepidoptera, as they advance in their family forms, are constantly throwing out hints and suggestions of forms that seem very strange to them, but become generalized in the group that tops them. Thus in the broad, irregular, net-veined, neuropterous fore wing, which becomes smaller and thicker in the orthopterous Blatta, and still more coleopterous in the hemipterous Corixa, we arrive at the perfected elytron, with its regular, obsolete veins and new protective function.

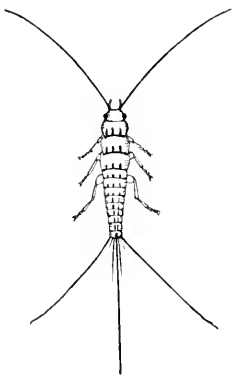
"Most of the examples above mentioned are familiar to entomologists, and others will occur no doubt to illustrate the subject more fully.

"Many authors have agreed that the suborders of insects can be arranged into two series or groups, often called Mandibulata and Haustellata, though disagreeing as to the relative rank of these two divisions, and the true places the suborders should occupy within them. It is enough for my purpose to assume that there are two such series, though believing that the two culminate in the Hymenoptera and Coleoptera respectively, in the succession that I have indicated above.

"What have we now in common with both, and which shall reunite this seeming polarity in the two series of suborders? There is needed a group which, while retaining its own strong fundamental features, and maintaining an equal footing with its equivalent groups, shall have besides the strongest analogies to those groups farthest removed by

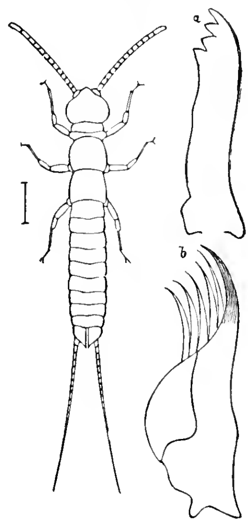
affinity, in order that these two series may be virtually brought together; while the successive forms in the several families shall afford us some conception of the larger categories these minor groups foreshadow. Such a group Professor Agassiz* has pointed out in the class of Selachians, which combine the characters of all the other classes of fishes existing during the same period, and also, by their being the earliest in time, afford what he calls *prophetic types*

FIG. 220.



Lepisma.

FIG. 221.



Campodea.

of all the coming classes of vertebrates. The former case affords what he calls *synthetic types*."

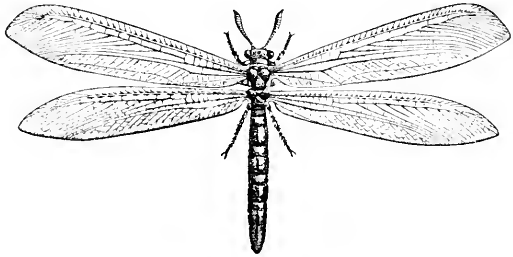
In endeavoring to show that a similar synthesis as marked as in the fishes or reptiles, or other groups of animals, occurs in the different neuropterous families of insects, the case of the *Lepisma* (Fig. 220, *L. quadriseriata*) or bristle tail, may be cited, which is closely allied to the Campodea (Fig. 221),

* Essay on Classification.

supposed to be a stem form of all the insects, and which is a remarkable synthetic type, combining the characters of the six-footed insects and the Myriopods.

The two families of May flies and dragon flies do not have any species with marked analogies to other insects. In an-

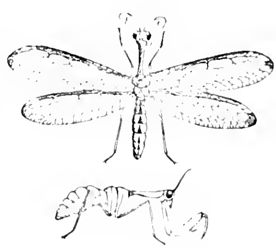
FIG. 222.



Adult of the Ant Lion.

other fam'ly, however, of which the adult of the ant lion (Fig. 222) is an example, we have the Ascalaphus, which was regarded by Scopoli as a Papilio, the wings being large and broad, and the antennæ knobbed. The neuropterous Mantispa (Fig. 223), in its fore legs adapted for seizing its prey, mimics the orthopterous Mantis. The Panorpa (Fig. 224), the type of another family of net-veined insects, assumes the shape of the crane flies (Tipula). Bittacus has its analogue in the fly named Bittacomorpha. The large lace-winged fly called Polystœchotes has some features reminding us of the Hepialus (Fig. 225). The Caddis flies imitate the Tineid moths so closely that excellent entomologists have confounded them. The species of Psocus mimic the Aphides so closely that they are often

FIG. 223.

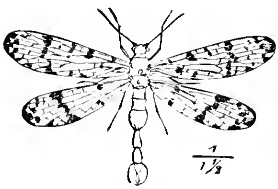


Mantispa.

mistaken for each other, and the wingless Atropos, or death tick, reminds us of the louse. The ants have among the Neuroptera their well known analogues, the Termites or white ants. Like the true ants they live in large colonies, and have wingless workers of two sorts. Now these and certain peculiarities in structure, which place the white ants at the head of the Neuroptera, are just those which make them so much like the true ants, which are among the most highly developed insects, ranking near the honey bee.

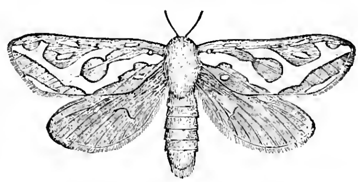
From the facts here and elsewhere given it may be regarded as quite well proved, that some, if not the majority of mimics among insects belong to groups, lower in the organic scale than the insects they mimic. Moreover, the paleontological record shows that the Neuroptera were the

FIG. 224.



Panorpa.

FIG. 225.



Hepialus.

first to appear. The fossil forms discovered were also synthetic types, combining the characters of other neuropterous and some orthopterous families. These fossil insects, it should be observed, were remarkable "mimics," but we have no proof that the living insects they resemble were then in existence. We can only explain the matter by regarding them as prophetic types, anticipating in nature the coming of whole families and even orders of insects. They represent ancestral or stem forms, from which arose lines of descent resulting in the present insect creation. The original Devonian May fly-like insect, and the Xenoneura and Homothetus, as well as the Carboniferous Miamia and Hemeristia and Eugereon, possessed features which they have, perhaps,

transmitted through different sources resulting in families whose distinguishing marks are based on the primordial traits united in the same insect, but now scattered in different families. For example, the raptorial fore leg and form of the head of the singular neuropterous insect, Miama, the peculiar veining of the wings, form characters now existing in two very different families.

Just as the embryo dog passes through a fish and a reptile stage before attaining its canine physiognomy, have the Neuroptera of the present day, in the process of building up new groups based on a modification of a single character, thrown aside the characters united in the more embryonic and primitive types. We would thus expect to find among the fossil insects the most startling anticipations of types not yet called into existence. The scanty paleontological record we have shows that the grasshoppers and their allies appeared after the Neuroptera; that the bugs (Hemiptera) appeared still later; that the moths and butterflies were very late in their arrival; that the flies probably preceded the Hymenoptera, and that the bees and wasps, the most highly developed structurally and intellectually of all insects, were the latest to be developed. It is a startling fact that the white ants which foreshadow so wonderfully the true ants, appear in great force in the coal formation, while the ants do not occur fossil before the Tertiary period. Now as an example of mimicry, any one ignorant of the geological record would regard the case of the white ants as one of the best, but the fact is the white ants were nearly as perfect, and doubtless as wonderful in their colonizing instincts in the Carboniferous period as in the age of man. Clearly, then, "mimicry" in the sense of being a factor in the origin of species does not as a rule exist, though there may be exceptions, and it is not improbable that a large proportion of so-called mimics are so by virtue of their similar physical surroundings. There have been cycles of creation, as if the

same thought were taken up in successive geological periods, and worked out in different ways, but with the same fundamental plan. The plan is the result of an unbroken line of forms transmitted by genetic descent; the variations in the typical forms have been induced by changes in the soil and air. These lines of development, from so-called archetypal forms suddenly stop, and we have to follow them back before we can again take up the thread of development of other lines. There is not a continuous chain of being, but lines of development sometimes parallel, but more often diverging and connected by cross ties and branches linking the animal creation into a whole, all converging to a primordial ancestor, perhaps no more highly organized than the structureless Moner, a drop of living, moving, self-reproducing protoplasm.

Turning now to the cases of mimicry in the butterflies described by Messrs. Bates and Wallace and Trimen, from South America, the East Indies and South Africa, respectively, all agree that the Heliconidæ are mimicked by other butterflies which are very unlike the members of their own families, and copy in form and color the Heliconidæ which, probably owing to a bad odor, are not eaten by birds, and thus multiply in great abundance. The object of the mimic is claimed to be a utilitarian one. It flies about in the disguise of a Heliconia, and were it not for this protection it and its offspring would become extinct. This resemblance, moreover, has probably, these authors claim, been brought about by natural and sexual selection. In the beginning some butterfly, through the tendency to variation assumed by Mr. Darwin, had a remote resemblance to a Heliconia; this favored it above its fellows, and the character growing more strongly marked became perpetuated, until after a great number of generations the similarity of form became perfected. Mr. Darwin adopts the view, and regards the mimicry as brought about by natural and sexual selection.

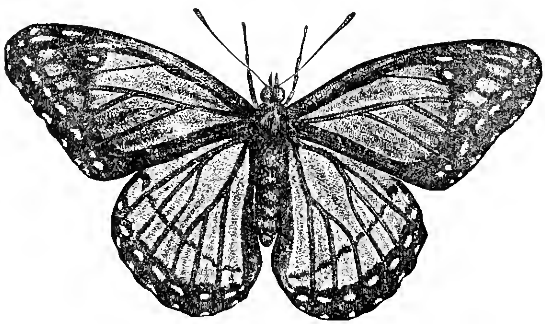
Bates says that a large number of the species of Heliconidæ "are accompanied in the districts they inhabit by other species which counterfeit them in the way described. The imitators belong to the following groups:—Papilio, Pieris, Euterpe, and Leptalis (family Papilionidæ), Protogonius (Nymphalidæ), Ithomeis, Erycinidæ, Castnia (Castniadæ), Dioptis, Pericopis, Hyelosia and other genera (Bombycidæ moths). I conclude that the Heliconidæ are the *objects imitated*, because they all have the same family facies, whilst the analogous species are dissimilar to their nearest allies—perverted, as it were, to produce the resemblance from the normal facies of the genus or family to which they severally belong. The resemblance is so close, that it is only after long practice that the true can be distinguished from the counterfeit, when on the wing in their native forests. I was never able to distinguish the Leptalides from the species they imitated, although they belong to a family totally different in structure and metamorphosis from the Heliconidæ, without examining them closely after capture. They fly in the same parts of the forests, and generally in company with the species they mimic."

In the United States we have a similar example, the only one known in this country. The *Danaus Disippus* is one of our most common butterflies. It is closely copied by the *Limenitis Archippus* (Fig. 226, from Tenney's Zoology), which is unlike in color every other known species of its genus. The Archippus enjoys immunity from the attacks of birds on account of its pungent odor, which is supposed to be disagreeable to them; hence it is very abundant. The Disippus butterfly, on the other hand, which is inodorous, is supposed to be mistaken by the birds for the Archippus, and thus multiplies in as great numbers as the pattern it copies. Such are the opinions of these distinguished writers.

It will be noticed that the Heliconidæ are regarded by Mr. Bates, and in this respect Mr. Trimen agrees with him,

as standing at the head of the group of butterflies, the Papilio usually being assigned to this position. Here, then, the mimickers are possibly lower in rank than the butterflies they mimic. This is certainly the case with the Castnia and the moths mentioned by Mr. Bates, and bears out our idea that the mimickers may have been produced in an age anterior to the origin of the Heliconidæ, and that the causes which produced the one perhaps originated the other. The

FIG. 226.



Limenitis Archippus.

mimickers created in a former geological period may have been preserved by virtue of their resemblance to butterflies originating at a later date.

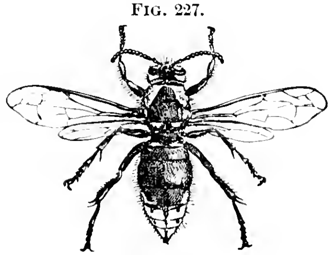
Many of the Bombycid moths are remarkable mimics of other moths, and this group, with the wide gaps in it, may be compared to the Neuroptera with their isolated genera and families. I regard the Bombycids as an ancient family in which time has made many inroads, and the relics which have come down to us may have owed their preservation largely to the protective mimicry of the caterpillars and cocoons to leaves and other objects, and of the moths to other moths.

Assuming, then, that protective mimicry has been an important factor in the preservation of species, we will exam-

ine a number of cases, some of which are not recorded so far as the writer is aware, but which any one can see for himself in his rambles out of doors.

The humble bees are mimicked by the Apathus, which takes up its abode in their nests. The peculiar relations existing between the Apathus and its host are not well understood. The Apathus is closely related to the humble bee, only differing from it in the structure of the jaws and hind legs, disabling it from gathering honey and pollen and caring for its young. Another well known mimic of humble bees is the Volucella, a large, plump, hirsute fly, in form and color closely copying the bee. Protected by this resemblance they enter the nests of their hosts, and their young devour the young bees. Bees are also mimicked by certain Syrphus flies (see Fig. 107) and by Laphria flies. The wasps are imitated often very closely by certain Syrphus flies (Fig. 26, *a*). The most extraordinary case of this kind is a Syrphus fly called Spilomyia. I once noticed this fly resting on a leaf in northern Maine, and involuntarily drew back, supposing it to be a white faced wasp (*Vespa maculata*, Fig. 227). It is smooth-bodied with the abdomen nearly cylindrical and thoroughly wasp-like. The position and form of the markings are almost exactly as in the wasp; the face is white, and the eyes are banded with white in imitation of the white orbits of the wasps. Even the abdomen or hind body is banded only towards the tip as in the wasp, while the legs are slashed with white much as in the wasp. Another Syrphus (*Epopter vittatus*), with a cylindrical body, is banded with bright yellow and resembles the *Vespa vulgaris*, while there are other species, such as *Doros balyrus*, which

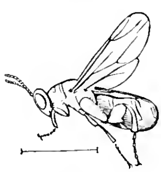
FIG. 227.



Vespa maculata.

resemble the Odynerus wasp. Other forms recall the mason bees, Osmia, and two green species (*Syrphus obscurus* and *Sargus obscurus*) recall Ceratina, the little green bee which tunnels the blackberry and syringa. The Euglossa, a bee with a remarkably long tongue, is mimicked by Pangonia, equally favored with a long beak. Wasps are also mimicked by lower Hymenoptera, as the large Chalcis fly, Leucospis (Fig. 228) which is so unlike others of its family. The Trypoxylon wasp with its club-shaped body is copied by the Conops, even to the peculiar hue of the front edge of the wings. Descending the scale of hymenopterous life we come to the Pompilus (Fig. 61), which is mimicked by the large black Mydas fly, whose antennæ are unusually long and hymenopterous-like. Certain ants are mimicked by species of Clerus beetles, which are colored in the same manner and run rapidly on the branches of bushes very much like ants. A certain beetle is called Formicomus from its resemblance to Formica, the ant.

FIG. 228.



Leucospis.

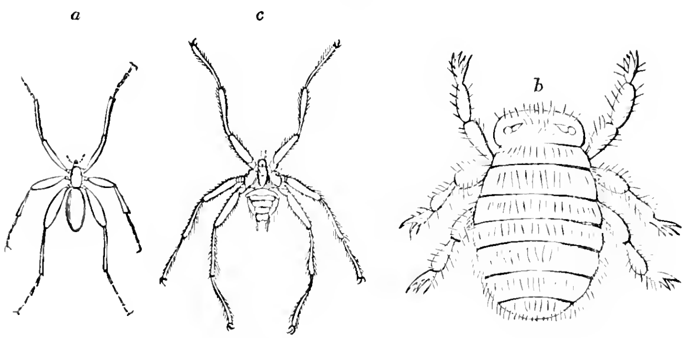
Among butterflies, the Papilio or swallow-tailed butterfly is very closely mimicked, both in form and color, by the highly colored swallow-tailed geometrid moth, Urania, and there is another geometrid moth that recalls the tailed Thecla. The Thyris moth is copied by the Desmia, a little black Pyralid moth, with large white spots on the wings.

On the other hand there are some moths which resemble so closely those of families below them that to this day in some cases entomologists have been mistaken in regard to them. The Doryodes with its feathered antennæ is in reality an owlet (Noctuid) moth, but has until recently been regarded as a geometrid moth allied to Aspilates. So with Boletobia and Pachycnemia, which are also Noctuid moths with analogies to the geometrid moths. Among the Bombycid moths are such forms as Euphanessa and Crocota which

remind us of geometrid moths, and they fly by day associated with them.

The wingless flies nearly always show a tendency to resemble spiders, from the wingless gnat-like Chionea (Fig. 229 *a*) down to the sheep tick, the bat tick (Fig. 229 *c*), and the bee louse (Fig. 229 *b*). I do not regard these, however, as cases of protective mimicry, but interesting

FIG. 229.



Chionea. Bat tick. Bee louse.

analogies resulting from the loss of wings and other degradational characters induced by their usually parasitic mode of life.

A singular case of mimicry may be observed in the moth Lycomorpha, so named by Dr. Harris from its resemblance when at rest to Lycus, which possesses broad wing-covers (elytra). The fore wings of the moth are shaped like the elytra of the beetle, the veins being much raised, like the ridges on the beetle's wings, while the arrangement of the colors is almost identical, and the antennæ of the moth are broad and flattened like those of the beetle.

The burrows of the mole cricket are, in North Carolina, as I have been informed by Mr. Shute, tenanted by a large bug, which has fore feet somewhat like those of the mole

cricket. Here the change in form has been evidently induced by its fossorial life, and we should not perhaps regard this as a case of protective mimicry. There are other bugs, of large size, with the legs provided with flattened expansions, like some long-horned beetles.

6

INSECTS AS ARCHITECTS.

11. Insects as Architects.

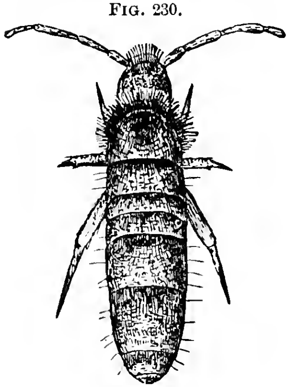
AN historical sketch of human architecture would scarcely begin with a description of the capitol at Washington, or of Westminster Abbey, or the still incomplete cathedral of Cologne, but would rather extend back to the earliest forms of human shelter, even to the pile dwellings of prehistoric Switzerland; nor would the historian disregard the rock shelters of Europe and this country, or the caves of Dordogne. In his accounts of the rise of the art of building he would be obliged to treat the subject after the method of the paleontologist, and reconstruct the primitive dwellings of the men of the reindeer period from the scanty relics of their age, with the aid of the huts and wigwams of savage tribes now living. Working out these problems, he would then reconstruct in the imagination the vast structure of Stonehenge, the palaces of the Aztecs, and would then be prepared to deal with the rise of architecture in Egypt, India and Greece.

So we may study the subject of insect architecture in the light of paleontology, and finding in the rocks the remains of lost tribes, judge what manner of builders they might have been by the work of their survivors of the present day, whose forms for aught we know are little superior to those of their ancestors of Devonian times, just as the savage of to-day is perhaps scarcely a step in advance of the wearer of the skull of Tuolumne valley, or the cave of Neanderthal.

Without much doubt the first cave-dweller was some Poduran (Fig. 230) or a Campodea-like being, if such lived in Presilurian times. They were the troglodytes of that misty period, living in holes in the earth, which wound their devi-

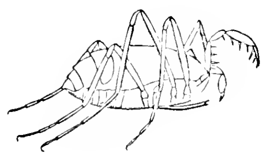
ous way under stones. There have been found in rocks of the coal period spider-like forms supposed to be allied to our modern harvest men, or the cave dweller of Wyandotte Cave (Fig. 231, after Cope), whose out-of-door relatives are said by Simon, a French entomologist, to burrow several feet deep in the porous soil of southern Europe. Associated with these fossils are found the remains of undoubted spiders, and in all likelihood they spun silken nests, and thus

FIG. 230.



Podura.

FIG. 231.



Erebomaster.

anticipated eons ago the light graceful iron work of our suspension bridges, crystal palaces and mammoth railroad stations.

But as early as the Devonian period, the time which ushered in the Coal epoch, when the ferns and land plants made their appearance, and the huge ganoids and sharks disported in the seas, at this early date insects resembling the May fly, but much larger, fluttered over the low shores and sluggish streams of our continent. Since they must have had the same organization as the modern Ephemera (see Figs. 117, 118) it is reasonable to suppose that they had the same habits. The first architects, then, so far as fossil evidence goes, in their larval stage lived in burrows con-

structed in the mud, or in rude tunnels beneath stones at the bottom of streams and ponds, or they supported their arched ways on the stalks of aquatic plants. These builders of Devonian times, in a way unconscious to themselves, tried the strength of their rude building material, practised the art of the mason, and applied the principles of the geometrician in their rough and ready mechanics.

In the Coal formation we find wings of fossil insects closely resembling our white ants, and belonging, perhaps, in the same family. Now some species of these insects are among the most skilled architects in the insect world. We shall see farther on how remarkable their large roomy dwellings are. Others construct tunnels in decayed trees. Our common white ant (*Termes flavipes*) is known either to mine the roots of grape vines, the trunks of elms, pine stumps, or to run secret galleries in the sills of houses, or to live under flat stones, with nests apparently like those of ants found in the same situations. Different species so far as we know have quite different habits. For example, the nests of *Termes arborum* are described by Smeathman as "surrounding the branch of a tree at the height of seventy or eighty feet; and (though but rarely of so large a size) as big as a very great sugar cask. They are composed of small particles of wood and the various gums and juices of trees, combined with, perhaps, those of the animals, and worked by these little industrious creatures into a paste, and so moulded into innumerable little cells of very different and irregular forms. . . . . These nests are very compact, and so strongly attached to the boughs on which they are fixed that there is no detaching them but by cutting them in pieces, or sawing off the branch." The nest communicates with the ground by covered ways leading to the roots of the trees. Again he describes some nests that resemble the complex nests of *Termes bellicosus*, but are smaller and of simpler construction. They are built in sandy plains, and

are "composed of a black mud, which is brought from a few inches below the white sand, and are built in the form of an imperfect cone, or bell-shaped, having their tops rounded. These nests are generally about four or five feet high." (Smeathman.) Other nests are built in the form of a mushroom.

The most elaborate architectural works, perhaps, undertaken by any insects are the nests of the *Termes bellicosus*, observed by Smeathman. Our figure (from Figuier, after Smeathman) will give an idea of the nest and its interior, with the Termes family grouped in the foreground. Smeathman, a traveller in Guinea, who published his account of these insects in 1781, claims, and we think with reason, that "the Termites resemble the ants also in their provident and diligent labor, but surpass them, as well as the bees, wasps, beavers and all other animals which I have ever heard of, in the arts of building, as much as the Europeans excel the least cultivated among the savages. It is more than probable they excel them as much in sagacity and the arts of government; it is certain they show more substantial instances of their ingenuity and industry than any other animals; and do in fact lay up vast magazines of provisions and other stores; a degree of prudence which has of late years been denied, perhaps without reason, to the ants."

The nests or "termitary" of this white ant are more or less conical or sugar-loaf-shaped, rising from ten to twelve feet above the surface of the ground. Indeed, they are said to be still higher by Jobson in his "History of Gambia," quoted by Smeathman as follows: "The Ant hills are remarkable cast up in those parts by Pismires, some of them twenty foot in height, of compasse to contayne a dozen men, with the heat of the sun baked into that hardnesse, that we used to hide ourselves in the ragged tops of them, when we took up stands to shoot at deere or wild beasts." (Purchas's Pilgrims, vol. ii, p. 1570.) Smeathman tells us

that on those he saw four men could stand with ease. The nests are ornamented with numerous conical turrets, sometimes four or five feet high. The walls of this dome are exceedingly hard and form a sort of shell protecting an interior building, divided into "an amazing number of apartments for the king and queen, and the nursing of their numerous progeny; or for magazines, which are always found well filled with stores and provisions." These colossal hills begin as little turrets a foot high; others are built near them, the highest one being built in the middle, until the spaces between are filled up and the whole built together into a single dome. This outer shell or dome not only protects and shelters the rooms within, but maintains an equitable temperature and moisture within, "very necessary for hatching the eggs and cherishing the young ones."

In the centre of the inner building near the base is the oven-like royal chamber, which is enlarged from an inch to six or eight inches or more in the clear as the queen increases in size. Here the king and queen are kept willing prisoners, as the entrances are only large enough to admit the workers which are much smaller. The royal chamber is surrounded by multitudes of smaller apartments which connect with the larger magazines and nurseries. The magazines are filled with provisions consisting of the gum of trees in small tears, resembling the sugar about preserved fruits. The nurseries containing the eggs and young are built of "wooden materials seemingly joined together with gums" and situated around the royal chamber.

All these apartments lead by arched passages into an open area or rotunda under the dome, which is compared by Smeathman to the nave of a cathedral. This nave "is surrounded by three or four very large Gothic-shaped arches, which are sometimes two or three feet high next the front of the area, but diminish very rapidly as they recede from thence like the arches of aisles in perspectives, and are soon

lost among the innumerable chambers and nurseries behind them." This nave is covered with a roof sufficient to keep the room dry during the heavy rains. This roof is not exactly flat because the workers "are always adding to it by building more chambers and nurseries; so that the divisions or columns between the future arched apartments resemble the pinnacles upon the fronts of some old buildings, and demand particular notice as affording one proof that for the most part the insects project their arches, and do not make them, as I imagined for a long time, by excavation."

The floor of the nave is very thick and forms the roof of the royal chamber, though containing several nurseries and magazines. "It is likewise water proof, and contrived, as far as I could guess, to let the water off, if it should get in, and run over by some short way into the subterraneous passages which run under the lowest apartments in the hill in various directions, and are of an astonishing size, being wider than the bore of a great cannon. I have a memorandum of one I measured, perfectly cylindrical, and thirteen inches in diameter."

These subterraneous passages or galleries are lined very thick with the same kind of clay of which the hill is composed, and ascend the inside of the outward shell in a spiral manner, and winding round the whole building up to the top, intersect each other at different heights, opening either immediately into the dome in various places, and into the interior building, the new turrets, etc., or communicating thereto by other galleries of different bores or diameters, either circular or oval." From these large galleries smaller ones extend to various parts of the building, and a great many run three or four feet under ground, where the Termites obtain the fine soil with which they build their nests. Other galleries," adds Smeathman, "ascend and lead out horizontally on every side, and are carried under ground near to the surface a vast distance; for if you destroy all

the nests within one hundred yards of your house, the inhabitants of those which are left unmolested farther off will nevertheless carry on their subterraneous galleries, and invade the goods and merchandizes contained in it by sap and mine, and do great mischief, if you are not very circumspect." Smeathman then remarks that the galleries are necessarily large, as they are the "great thoroughfares for all the laborers and soldiers going forth or returning upon any business whatever, whether fetching clay, wood, water or provisions; and they are certainly well calculated for the purposes to which they are applied, by the spiral slope which is given them, for if they were perpendicular the laborers would not be able to carry on their building with so much facility, as they ascend a perpendicular with great difficulty, and the soldiers can scarce do it at all. It is on this account that sometimes a road like a ledge is made on the perpendicular side of any part of the building within their hill, which is flat on the upper surface, and half an inch wide, and ascends gradually like a staircase, or like those roads which are cut on the sides of hills and mountains, that would otherwise be inaccessible; by which, and similar contrivances, they travel with great facility to every interior part.

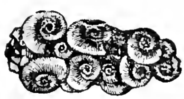
"This too is probably the cause of their building a kind of bridge of one vast arch, which answers the purpose of a flight of stairs from the floor of the area to some opening on the side of one of the columns which support the great arches, which must shorten the distance exceedingly to those labourers who have the eggs to carry from the royal chamber to some of the upper nurseries, which in some hills would be four or five feet in the straightest line and much more if carried through all the winding passages which lead through the inner chambers and apartments."

Whether the work of these white ants is due to the operations of a "blind instinct" or unconscious automatism may well be doubted. It should be borne in mind also that the

insects belong to the lowest division of the winged insects, and, even geologically speaking, to a very ancient stock. It is significant to find developed in them such a high degree of architectural skill.

The mechanical ingenuity of the case worms is shown in the construction of their cases. These are ancient types of insect forms thought to be in some respects similar to those occurring in the coal formation, while undoubted caddis-flies occurred in the Wealden strata of the Lower Cretaceous formation. Sir Charles Lyell assures us that "a large species of caddis-worm, which swarmed in the Eocene lakes of Auvergne in France, was accustomed to attach to its dwelling the shells of a small spiral univalve of the genus Paludina." It must have resembled the cases of the British *Limnophilus flavicornis*, whose case (Fig. 232) is covered with little fresh water snail shells. Other examples of the work of these interesting insects are given on page 132. They gather bits of leaves or sticks, or particles of gravel, with their jaws, and arrange them around their body, covering their hind body first and then building on to the anterior end, gluing the particles together by means of a silky secretion. They probably do not use their fore legs in this process, at least the clothes moth does not in constructing a similar case. Other cases are made by rolling up a strip of leaf deftly cut out of the required length and width, as seen in Fig. 92, while others, more careless, attach broad, irregular pieces to their cases.

FIG. 232.

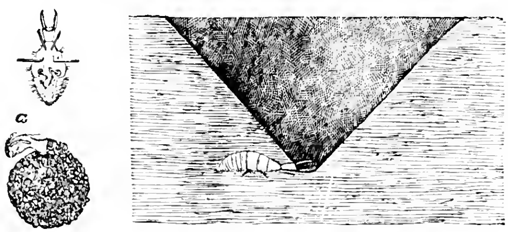


Case worm.

Another net-veined insect which shows much ingenuity in the construction of its dwelling, and much low cunning in providing itself with food, is the ant lion. This is the larva of the Myrmeleo. Its body is broad and flat, armed with enormous scissor-like jaws which project straight out from the head. It lives in colonies, sometimes numbering over

six hundred individuals, each lying at the bottom of its hole. Mr. Emerton has described, in the "American Naturalist" (iv, p. 705), the habits of our *Myrmeleo immaculatus* (Fig. 233, with the larva seen from beneath, and the pupa). It digs a pit in the sand an inch deep and two inches in diameter. Mr. Emerton thinks the ant lion begins its hole by making a circle and afterwards throwing out the sand from the centre. "In digging he used his flat head and jaws, which were pushed under several grains of sand and then jerked upwards, throwing their load sometimes as far as six inches, and always far enough to avoid leaving a ridge around the pitfall. When the pit was finished he was entirely concealed beneath it, as in Fig. 233, except his jaws,

FIG. 233.



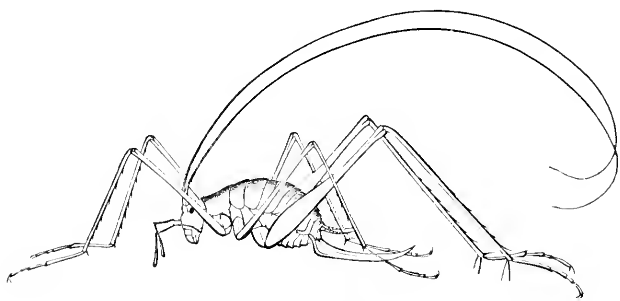
Ant Lion and its pit.

which were spread apart horizontally at the bottom. The surface of the pit being as steep as the sand could be piled up was very easily disturbed, and when an insect ventured over the edge the ant-lion was apprised of it at once by the falling sand. He immediately began to throw up sand from the bottom, deepening the pit, and so causing the sand to slip down from the sides and the insect with it. The ant-lion seized it with his long jaws and held it up above his head, until he had sucked all he wanted from it, when he threw the remainder out of the hole and repaired the trap. . . . After eating he became more timid and sometimes would not take a second insect. If, however, several were

put into the pit at once, he would bite one after the other until all were killed, before deciding on which to begin."

While the grasshoppers do not construct nests, they have various methods of securely depositing their eggs either in the earth or in rotten wood or on the surface of leaves. The wingless grasshoppers avail themselves of rocks as shelters, a notable example being the wingless grasshopper of Mammoth and other caves in Kentucky (Fig. 234). The English cricket is said by White, in his "Natural History of Selborn," to form burrows in the earth, but this habit has not yet been discovered in our American species. The mole cricket, however, is known to burrow in damp places in this country,

FIG. 234.



Cave Grasshopper.

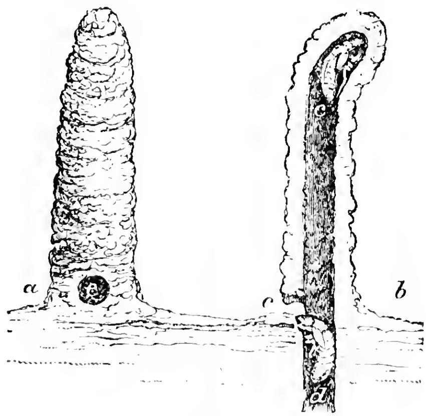
as well as Europe, where it forms an oven-like chamber in which it deposits about a hundred eggs. It also constructs extensive galleries, similar to, but smaller than, those of the mole. The tunnel runs just under the surface of the soil, and may be detected by the slightly raised ridge of soil like that made by the mole.

Among the bugs (Hemiptera) the only species we can now recall as constructing a domicile is the young of the seventeen-year Cicada. Our figure (235, after Riley) represents the conical nests raised above the surface of the soil in wet and damp places, rising from four to six inches above

the ground, with a hole (*e*) at the base. Mr. Rathvon, who observed this fact, says that the pupæ await in the upper end of these chambers their time of transformation into the winged state, and when about to come from the ground, move backwards down the tube to below the level of the earth as at *d*, "and issuing forth from the orifice would attach themselves to the first object at hand, and undergo their transformations in the usual manner."

Many plant lice allied to the Aphis, by their punctures cause the adjacent parts of the leaf to curl over and conceal

FIG. 235.



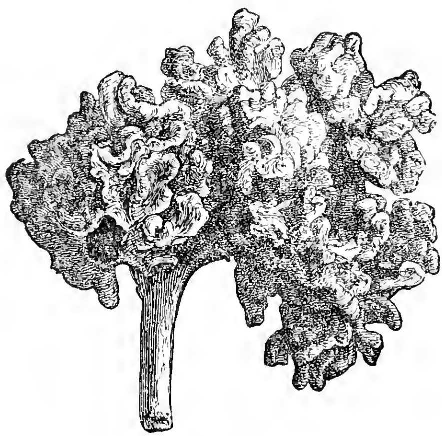
Young 17-year Cicada and its nest.

them, or even give rise to the true galls, as elaborate as those of the gall fly. A kind of Pemphigus forms on the sumac the irregular growth represented by figure 236 (after Riley). The cock's-comb elm gall (Fig. 237, after Riley) often occurs in great numbers on the leaves of the white elm. "By the end of June or the beginning," says Mr. Walsh, "the gall becomes full of winged plant-lice, when the slit on the upper side of the leaf, tarough which the mother plant-louse built up the gall early in the spring, gapes open and

allows the insects to escape into the open air." These galls can scarcely be regarded as evidences of architectural skill, as they are indirectly due to the simple punctures of the beak of the insect, not to an intellectual act.

Among the beetles we shall not find evidence of any considerable skill in building. The habit of the Chlamys of building a compact little case has already been referred to. Its case is black, and appears to be formed of little pellets of excrement, with a seam along the middle of the under

FIG. 236.



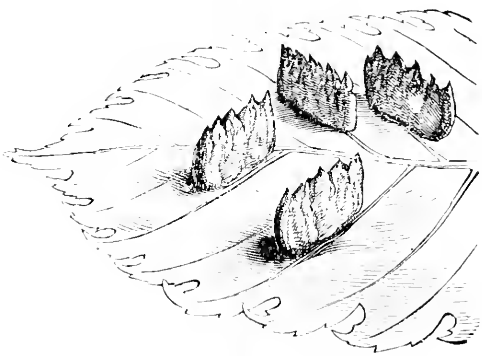
Sumac gall.

side, which readily spreads open when the sac is pressed. The case is slightly contracted at the entrance, where the pellets are a little larger than elsewhere.

The weevils are the lowest of the beetles, and yet they display in some cases great ingenuity in providing appropriate places in which to lay their eggs. I have often watched the doings of the *Attelabus rhois* (Fig. 238 represents another species, *A. analis*) while rolling up the leaves of the alder. Late in June and during the early part of July in

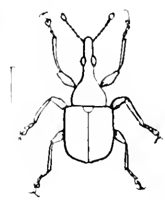
Maine I observed the female while engaged in making one of these singular thimble-like rolls. When about to deposit an egg, she picks up a leaf with her mandibles, and begins to cut with her jaws a slit near the base of the leaf on each side of the midrib, and at right angles to it, so that the leaf may be folded together. Before beginning to roll up the leaf she gnaws the stem nearly off, so that after the roll is made, and has dried for perhaps a day it is easily detached by the wind and falls to the ground. Then folding the leaf, she tightly rolls it up with her jaws and legs, neatly tucking in the ends, until a compact cylindrical solid mass

FIG. 237.



Cock's-comb gall.

FIG.



Attelabus.

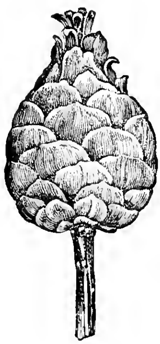
is formed. Before the roll is completed she deposits a single egg, rarely two, in the middle, next to the midrib, where it lies loose in a little cavity. While she is thus engaged, her partner, a little smaller, may often be seen watching her from the other end of the leaf, but never lending his aid, as in the case of the timber beetles. The roll serves as a mass of food for the young grub to feed upon, and may be regarded as an artificial bud.

The larvæ of the Tiger beetles have the requisite instinct to make deep tubular pits in which they lie in wait for their

prey. The construction of their nests does not require so much intelligence as is shown by the ant lion. The larva is a hideous being, with a large horn on its back, by which it is enabled to prop itself up in its hole.

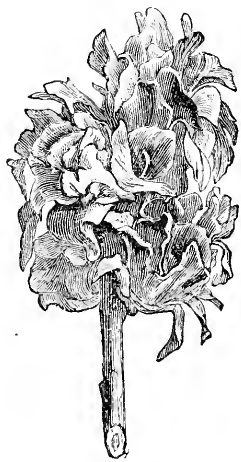
None of the flies are architects. Some involuntarily form galls of various shapes, in which the maggots are domiciled. For example, the gall-fly of the willow forms the familiar pine-cone-like swelling (Fig. 239) found on willow twigs, while another kind forms a mass of willow leaves like the

FIG. 239.



Willow gall.

FIG. 240.



Cabbage willow gall.

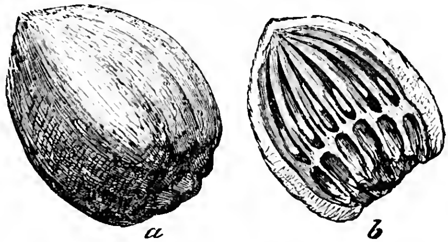
sprouts on a cabbage (Fig. 240). The many-chambered gall of the gall-gnat of the grape vine is represented by figure 241 (this and the two preceding figures from Riley), and Mr. Riley has delineated the filbert gall which grows in large masses on the grape vine (Fig. 242, representing a mass of them of the natural size).

Among the caterpillars of the moths are many of the smaller kinds which mine the leaves of plants, or tunnel the stems; others, more skilful, cut out portions of leaves and

convert them into sacks which they bear about with them, much as in the caddis worms. The young clothes moth (Fig. 243, *a*, its sack; *b*, chrysalis) bites off pieces of the woollen cloth on which it feeds, sticks them together by means of a silky secretion, and thus forms a close, dense sac. As it grows, instead of throwing away the sac it has outgrown, it makes a slit on each side, fills in the rent with new material, and adds more to the mouth, thus enlarging and refitting its house.

Certain small caterpillars of the Acrobasis and other allied genera economize their excrement, constructing between the

FIG. 241.



Many-chambered Grape Gall.

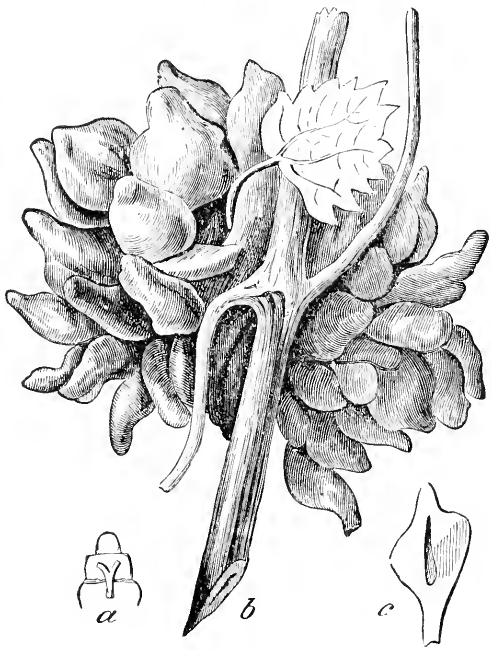
leaves of the birches, on which they feed, little trumpet-shaped cases out of the little black pellets.

The case of the "basket worm" is a curious object. Fig. 244 (*a*, moth; *b*, wingless female; *c*, larva; *d*, case) represents the different stages of growth of a small species found in Florida by Mr. T. Glover. Our common basket worm is a familiar object in the middle and southern states. Its case is about two inches in length, and while the interior is lined densely with silk, on the outside are stuck pieces of cedar twigs and leaves, sometimes half an inch in length. We have seen the young just after leaving the egg beginning to build their cases, which are at first broad and shallow like a basket; and it is a comical sight to see the little tiny worms creeping rapidly along, their tails held straight up in

the air, capped by this basket, reminding one of a small boy walking along with a large bushel basket over his head.

Then there are the tent caterpillars, which spin from their mouths an immense quantity of silk, out of which they build large tents between the branches of trees, and run rope-walks along the upper side of all the branches leading away

FIG. 242.



Filbert Grape Gall.

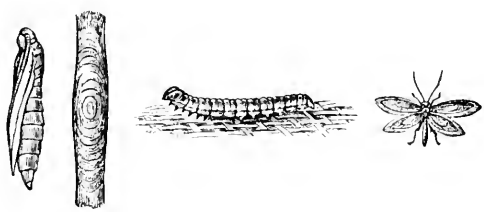
from their tent. The nest of a species of Tortrix which lives on the wild cherry consists of a large mass of leaves sewed together with silk, forming a shelter from the heat and rain and a protection from the birds.

There are numberless modifications of leaf-rolling habits among the smaller caterpillars, but after all no insects, with

the exception of the Termites, present such evidences of mechanical skill as the bees and wasps and ants. The Hymenoptera, of which they are the most familiar examples, were among the latest insects to appear on the surface of the earth. The lower forms, so far as the scanty records show, appeared first in the Jurassic rocks, while the ants are first found in the amber of the Tertiary period, so that the ants and wasps and bees were in all probability among the latest insect creations. This inference is borne out by the fact that the individuals and species are very abundant. Did they belong to an ancient stock their numbers would have been thinned out.

The lowest hymenopterous insect which lives in a house of its own, not, however, made with its own hands, is a kind

FIG. 243.



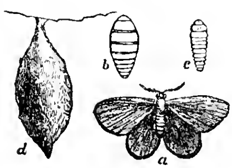
Clothes Moth.

of saw-fly (Euura), which constructs a gall. The female lays an egg in the bud of a willow; the presence of the egg sets up an irritation, causes an unnatural enlargement of the bud-leaves, until a round swelling or tumor is formed, in which the false-caterpillar lives and feeds on the walls of its house, which grows with its growth. Mr. Walsh has studied these gall saw-flies. The gall in which *Euura orbitalis* lives is at first a bud which is enlarged two or three times its natural size before it unfolds in spring. In the autumn it bores through the walls of its dwelling, and descends to the ground, burrowing an inch deep below the surface. Here it

spins a thin, silken, whitish cocoon. Other species take up their abode in galls made by two-winged gall gnats, and are hence called guest or "inquiline" saw-flies. These galls are sometimes inhabited also by a caterpillar, so that we have a saw-fly caterpillar, a true caterpillar, and a maggot making use of the same kind of gall. They do not, however, crowd into the same domicile at once. In this case at any rate nature does not set the laws of hygiene at defiance, and crowd two or three families in a single room. The necessities of modern civilization, or an outgrowth from it in our cities, crowd several families in a single room. Is not a human life of as much account as a caterpillar's?

The saw-flies with their exceptional gall-making habits anticipate in nature the true gall flies, those singular beings to whom a gall is their world, and the gall of bitterness a perennial fountain of nectar. To these little white maggots, the young gall flies, the poor scribbler who is obliged like Douglas Jerrold to feed his family "out of an inkstand," owes his all. Quite unconscious of the responsibility resting upon him, our maggot, truly an "unconscious automaton," by its simple presence in the leaf or stem, and with no more intention to be an agent in bringing about a desired result than though it were a grain of sand, lies passively in its cell, while the growth-force of the plant erects a house over and around this foreign body. No more intellectual act is needed on the part of the guest than in its unconscious host, the plant. The case of the gall maggot is an excellent example of "unconscious automatism," while I imagine the reader will agree with me that the case of the white ant, or the true ants, as well as many bees and wasps, is of an entirely different order and carries us into a sphere where the sensibilities, the will, and the intellect exert at least some force.

FIG. 244.

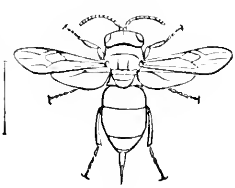


Basket Worm.

The largest gall we have is made by the *Cynips confluens*, found on the scrub oak. It sometimes attains a diameter of two inches. It begins to form as soon as the leaves unfold. It is at first green and pulpy and has a central kernel in which the maggot resides. When the gall is ripe the shell becomes hard and dry, and after the fly has escaped, which occurs in June and again in October, the deserted shell is often tenanted by wasps. Some galls, as the bedeguar of the rose, are covered with vegetable hairs, and the variety of form in others is very great. On the raspberry and blackberry, as well as the blueberry, occur different sorts of galls. All are the result of the sting of the female, which is thought by some to convey a poison into the wound, though it is a question whether the egg introduced by the sting or ovipositor does not act as an irritant body, causing an excessive flow of sap and accumulation of cells resulting in the formation of a tumor.

Passing by the ichneumon flies, which after all have the best of it, as they are tenants of living homes, supplied with the choicest of food at no trouble and expense to themselves, we come to the cuckoo flies. The Chrysis (Fig. 245) is not a true wasp, but is in some respects allied to it. Its integument is very hard and thick, and beautifully tinted with green and blue and various metallic colors. When assailed it rolls itself into a ball, in the manner of a pill bug. Its sting is large and exceedingly painful, but not poisonous. The Chrysis is called a cuckoo fly, as it has the ichneumon trait of living at the expense of other insects. This fly may often be seen flying about posts and hollow stalks of plants, exploring the holes of wasps and bees, where they lay their eggs. The young hatch out some time after the larval bee or wasp, and then attack the latter, sucking its

FIG. 245.

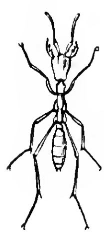


Chrysis.

blood. The patience and perseverance under great natural difficulties, the danger to which they are exposed from the attacks of their unwilling hosts would form an interesting chapter, but we must come now to the true builders.

The ants are their own architects, their own masons and laborers. I shall not now speak of their colonies and complex mode of life. It is well known that the workers carry on the labors of the colony, and to these beings, which have not the power of transmitting their qualities, but inherit them from their parents, has been imparted a high degree of skill, in fact, somewhat of those qualities which characterize the highest types of human civilization; for, while ants are fully capable of defending themselves, and as every body knows are bold and aggressive to a fault, they also excel in the arts of peace.

FIG. 246.



Driver Ant.

As bridge-makers they have anticipated our civil engineers. The driver ants, Anomma (Fig. 246), which are blind, are said by Dr. G. A. Perkins, who has observed them in Western Africa, to "often bridge narrow streams of water when these come across their path, by going in large numbers upon a flexible plant on one side of a stream, until their weight causes it to bend to the other side." This ant is certainly equal, in this respect at least, to the monkeys which are said to cross streams in a similar manner.

But it is in the construction of underground tunnels that ants are preëminent. The late Gideon Lincecum, so well known for his acute powers of observation, in an account of the *Œcodoma Texana* states that "they often carry their subterranean roads for several hundred yards in grassy districts, where the grass would prove an impediment to their progress. On one occasion, to secure access to a gentleman's garden, where they were cutting the vegetables to pieces, they tunnelled beneath a creek which was at that place fifteen or twenty feet deep, and from bank to bank

about thirty feet. Another species in Brazil, according to Rev. Hamlet Clark, will tunnel a ditch, and he adds, "Indeed, I have been assured again and again by sensible men, that it has undermined, in its progress through the country, the great river Paraiba, as broad as the Thames at London Bridge; at any rate, without anything like a natural or artificial bridge, it appears on the other side and continues its course."

It would be exceedingly interesting to watch the successive steps of this tunnelling process, to learn how they plan their work, how the mine is run under the stream with such true engineering skill from one side to the other; how the danger of undermining and flooding are overcome. Here we have a slight anticipation of the Thames tunnel, though this is said to have been suggested by the tunnel of the ship worm, which lines its hole with limestone.

Ants also dig wells. The same Texan Œcodoma, we are told by Dr. Lincecum, needs water as much as cattle or men, and like the latter they dig their own wells. In one case, where a man dug a well reaching water at a depth of thirty feet, the ants dug a well to the same depth, with a diameter of twelve inches.

As mound builders the ants are indefatigable. With the aid of their jaws they carry out grain after grain of sand, and from being primarily tunnellers, they become mound-builders. An ant hill, common object as it is, is a marvel of patient and untiring labor. Think of the toil and muscular exertion spent by these ants in climbing from the depths below up the perpendicular walls of their nests with their burdens; and busy as they appear to us by day, they are said to do the greater part of their work by night. In clayey countries in Mexico the Œcodomas build enormous ant hills, "so that one perceives them from afar by the projection which they form above the level of the soil, as well as by the absence of vegetation in their immediate neighbor-

hood. These nests occupy a surface of many square metres, and their depth varies from one to two metres." (Sumichrast.)

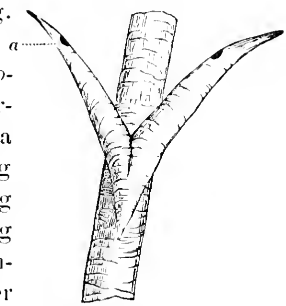
The exact height of these ant hills is not stated. The largest earthen nests of which we have any account are those described by the Jesuit Dobrizhoffer and alluded to by Westwood in his "Introduction to the Modern Classification of Insects." The conical nests of these ants, which abound in the plains of Paraguay, are said to be as hard as stone and "three or four ells high." A Flemish, English and French ell are three, five and six quarters of a yard respectively; which measurement is intended by the Portuguese writer or Prof. Westwood is not stated. By English measurement the hills would be about twelve feet high. This is the only case where the hills of the ants emulate in size those of the Termites. Our largest native nests are made by the *Formica sanguinea*, or common large red ant, and consist of sand or clay, according to the nature of the ground. Undoubtedly the object of the ants in making the hills is to keep the water out of their burrows, but in Labrador, where it rains nearly every other day, I have observed that this or an allied species makes no hillocks, but lives exclusively in underground passages.

Another kind of ant attains a still higher degree of civilization. The Agricultural ant of Texas, studied for so many years by Dr. Lincecum, is said by him (in the "American Naturalist") to build paved cities and construct roads. In a year and a half from the time the colony begins, the ants previously living concealed beneath the surface, appear above and "clear away the grass, herbage and other litter to the distance of three or four feet around the entrance to their city, and construct a pavement, ... consisting of a pretty hard crust about half an inch thick," formed of coarse sand and grit. These pavements would be inundated in the rainy season, hence, "at least six months previous to the coming of the rain," they begin to build mounds rising a

foot or more from the centre of the pavement. Within these mounds are neatly constructed cells into which the "eggs, young ones, and their stores of grain, are carried in time of rainy seasons." In another place he adds that "some old settlements have a pavement fifteen feet in diameter and a mound in the centre a foot high." The roads extend for half a mile from the "formicary," or ant hill.

One kind of Mexican ant (*Pseudomyrma flavidula*) is known to live within the spines of the Mimosa, the hole for the entrance and exit of the ants being made near the end (Fig. 247, *a*).

FIG. 247.



Ant nest in thorns.

In India, a greenish ant (*Œcophylla smaragdina*) is said by Jerdon to form a nest, sometimes a foot in diameter, by drawing living leaves together without detaching them from the branch, and uniting them with a fine white web. Another Indian ant, like the paper wasp, "makes a small nest about half an inch, or rather more, in diameter, of some papyraceous material, which it fixes on a leaf." (Jerdon.) The ants belonging to the genus Crematogaster, and which from their resemblance to a wig are known by the popular name of "Negro-head" in Brazil, according to Mr. F. Smith, "construct their nests on the branches of trees, suspending them in the same way as wasps, to the nests of which they have a close resemblance; on removing the outer covering, however, they exhibit a very different construction, being composed of multitudinous, curved, intricate ramifications, all leading to the interior chambers and galleries."

There are many sand wasps which excavate holes in the ground, and deposit at the bottom of their burrow living but paralyzed insects among which they lay their eggs. A

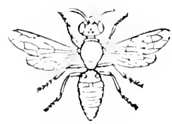
typical example is the Sphex (Fig. 59) whose habits have already been described. The mud dauber (*Pelopæus flavipes*) is a slender form, brightly banded and spotted with yellow, and is found all over the country. Her cells of pellets of mud plastered on the wall of a house are common objects known to every school boy. These cells are built of layers of mud of unequal length, the pellets being placed in two rows, diverging from the middle. They are a little over an inch in length and about half as wide, and are seen in section to be triangular in outline. The larva within spins a brown silken cocoon, after eating up the store of paralyzed spiders, whose remains may often be found tucked away at one end of the cell. Several cells usually occur together, covered over with a common layer of mud.

This habit of collecting materials for their nests is shown more distinctly in the black Sphex (*S. tibialis*) which forms its nest in the tunnels previously made by the carpenter bee in a piece of pine board. In an example described in my "Guide to the Study of Insects," the hole was six inches long, and the oval, cylindrical cocoons were packed loosely, either side by side, where there was room, or in a single row. The interstices between them were filled with bits of rope, which appeared as if they had been bitten in pieces by the wasp itself, while the end of the cell was filled for a distance of two inches with a coarse sedge arranged in layers, as if rammed in like gun wadding.

Another exception to the burrowing habits of the sand wasps is afforded by a Brazilian species of Larrada, which, according to Mr. Bates, builds a nest "composed apparently of the scrapings of the woolly texture of plants; it is attached to a leaf, having a close resemblance to a piece of German tinder, or a piece of sponge." In thus availing itself of the scrapings of the bark of plants, we have a slight anticipation of the paper-making wasps. The wood wasps evince fully as much, if not more, architectural skill

than the sand wasps. The different species of Crabro, with their large cubical heads, the Philanthus (Fig. 248) and Cerceris, refit old nail holes and tunnel rotten wood, filling their holes with aphides, caterpillars, beetles and spiders, etc. The European *Philanthus apivorus* has the unfortunate habit of provisioning its nest with honey bees; so also with a species of Cerceris. The smaller, blackish species have the most interesting habits. In Europe, according to Prof. Westwood, the prey of a species of Oxybelus consists of flies, "which it has a peculiar mode of carrying by the hind legs the while it either opens the aperture of its burrow, or else forms a new one with its anterior pair."

FIG. 248.



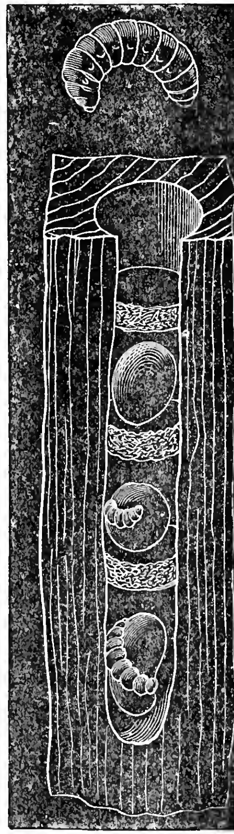
Philanthus.

A Trypoxylon wasp was detected in England frequenting the holes of a post preoccupied by a species of Odynerus, a solitary wasp closely allied to the social paper wasps, "into which it conveyed a small round ball, or pellet, containing about fifty individuals of a species of Aphis; this the Odynerus, upon her return, invariably turned out, flying out with it, held by her legs, to the distance of about a foot from the aperture of her cell, where she hovered for a moment, and then let it fall; and this was constantly the case till the Trypoxylon had sufficient time to mortar up the orifice of the hole, and the Odynerus was then entirely excluded; for although she would return to the spot repeatedly, she never endeavored to force the entrance, but flew off to seek another hole elsewhere." The stems of the syringa, elder, blackberry and other pithy shrubs are also favorite nesting places of these wood wasps. Several species have been found by Mr. Angus nesting in the stems of the syringa; all their nests have a family resemblance, being simple tunnels, without any pretensions to architectural skill.

The stems of the blackberry or syringa are often tenanted by the little green Ceratina bee. Figure 249 represents a

syringa stem containing the cells of this bee, separated at regular intervals by little parchment partitions, the spaces between them being filled with dirt. The cells are filled by the parent bee with pollen, a store of food for the grub.

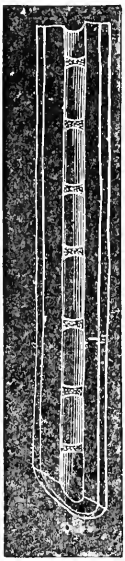
FIG. 250.



Nest of Carpenter Bee.

A great step in advance is the home of the carpenter bee (Fig. 250), which is bored in solid pine wood or even hard wood, sometimes for a foot or more. The work is done by the jaws of the bee, and the hole is bored as evenly as by an auger. After boring the hole, it is partitioned off by chip walls, a pellet of pollen on which the larva feeds having been previously placed in each cell. Here is a specimen of mechanical ingenuity and architectural skill which is certainly surprising, and indicates some forethought and a certain degree of reasoning power.

FIG. 249.



Nest of Ceratina.

In the succeeding chapter the nests of the social wasps and bees will be noticed, as the high degree of architectural skill shown by these insects is intimately related with the complex economy of the colony.

12. The Social Life of Insects.

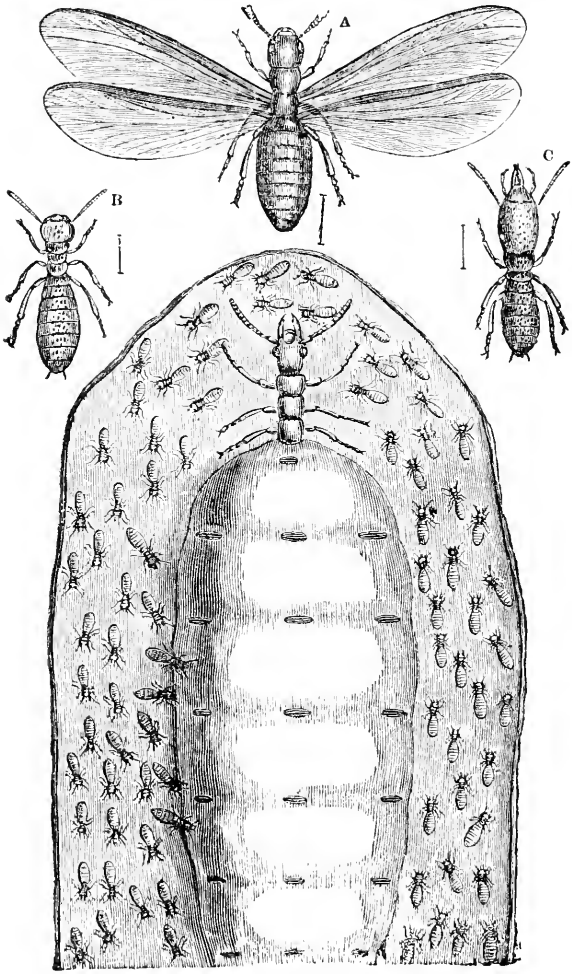
MANY of the lower animals, from being hatched from the same mass of eggs, live in broods and are gregarious; or certain animals, like the coral polyps, some ascidians, and moss-animals, are compound, with even, as in the latter, possibly a common nervous system, forming a colonial system of organs which simultaneously minister to the wants of the whole community; but though such animals are called social, the term is a misnomer.

A true sociability exists for the first time, rising in the scale of life, among the white ants. Here one set of individuals directly minister to the wants of others; all are dominated by their interest and devotion to the head of the colony, the queen, and all work together for the common good of the entire community.

Let us turn again to Smeathman's work for a general view of the in-door life of this busy people, this model republic, whose domes rose above the tall reeds of the low Guinea coast centuries before Plato wrote his "Republic."

"Of every species," says Smeathman, "there are three orders: first, the working insects, which, for brevity, I shall generally call *labourers;* next, the fighting ones, or *soldiers*, which do no kind of labour; and last of all, the winged ones, or *perfect insects*, which are male and female, and capable of propagation. These might very appositely be called the *nobility* or *gentry*, for they neither labour, nor toil, nor fight, being quite incapable of either, and almost of self-defence. These only are capable of being elected kings or queens; and nature has so ordered it, that they emigrate within a few weeks after they are elevated to this state, and either establish new kingdoms, or perish within a day or two."

FIG. 251.



Female, worker and soldier Termes.

Our illustration (Fig. 251, A, adapted from Smeathman by Figuier) represents the winged female of *Termes lucifugus*, enlarged four or five times, the line indicating her natural length; D represents the wingless female of *Termes bellicosus* of the natural size, with her hind body distended with eggs, the original segments being greatly enlarged. She is surrounded with numerous workers; B represents one of the workers of *Termes lucifugus*, magnified four or five times. It will be noticed that the head of the worker or laborer is quite small compared with that of the soldier of the same species (C), in which the body is nearly twice as large, while the head is enormous and armed with long scissors-like jaws, for purposes of attack and defence. There are about one hundred laborers to one soldier.

The winged females are found flying about at the beginning of the rainy season. After being on the wing for a few hours they descend to the ground, where they are at once attacked by the true ants, which drag multitudes of them into their nests, so that Smeathman remarks that "it is wonderful that a pair should ever escape so many dangers and get into a place of security. Some, however, are so fortunate; and being found by some of the labouring insects that are continually running about the surface of the ground under their covered galleries, which I shall shortly describe, are elected *kings* and *queens* of new states; all those who are not so elected and preserved certainly perish, and most probably in the course of the following day.

"The manner in which these labourers protect the happy pair from their innumerable enemies, not only on the day of the massacre of almost all their race, but for a long time after, will I hope justify me in the use of the term election. The little industrious creatures immediately enclose them in a small chamber of clay suitable to their size, into which at first they leave but one small entrance, large enough for themselves and the soldiers to go in and out, but much too

little for either of the royal pair to make use of; and when necessity obliges them to make more entrances, they are never larger; so that of course the *voluntary subjects* charge themselves with the task of providing for the offspring of their sovereigns as well as to work and to fight for them until they shall have raised a progeny capable at least of dividing the task with them."

It is not until this time that the nuptials of the royal pair take place. The queen then lays her eggs "to the amount of sixty in a minute, or eighty thousand and upward in one day." Meanwhile the laborers, "having constructed a small wooden nursery, as before described, carry the eggs and lodge them there as fast as they can obtain them from the queen." These nurseries may be in some cases "four or five feet distant in a straight line, and consequently much farther by their winding galleries." "Here," adds our author, "the young are attended and provided with everything necessary until they are able to shift for themselves, and take their share of the labours of the community."

As an illustration of the wonderful intelligence of these social Termites as compared with that of solitary insects, Smeathman, in speaking of their numerous underground galleries by which they go about in the neighborhood of their nests with the utmost security in all kinds of weather, says that "if they meet a rock or any other obstruction, they will make their way upon the surface; and for that purpose erect a covered way or arch, still of the same materials, continuing it with many windings and ramifications through large groves; having, where it is possible, subterranean pipes running parallel with them, into which they sink and save themselves, if their galleries above ground are destroyed by any violence, or the tread of men or animals alarms them. When one chances by accident to enter a solitary grove, where the ground is pretty well covered with their arched galleries, they give the alarm by loud hissings, which we hear

distinctly at every step we make; soon after which we may examine their galleries in vain for the insects, but find little holes just large enough for them, by which they have made their escape into their subterraneous roads. These galleries are large enough for them to pass and repass so as to prevent any stoppages (though there are always numerous passengers) and shelter them equally from light and air, as well as from their enemies, of which the ants, being the most numerous, are the most formidable."

How well the soldiers perform their duty and the laborers theirs, is described by Smeathman, who says that "if you make a breach in a slight part of the building, and do it quickly with a strong hoe or pick-axe, in the space of a few seconds a soldier will run out, and walk about the breach, as if to see whether the enemy is gone, or to examine what is the cause of the attack. He will sometimes go in again, as if to give the alarm; but most frequently, in a short time, is followed by two or three others, who run as fast as they can, straggling after one another, and are soon followed by a large body who rush out as fast as the breach will permit them." They then attack in their blind rage whatever object they come in contact with, whether the leg or foot of the curious naturalist who has made the disturbance, all the time making a crackling noise with their jaws, beating them on the sides of the building. When all is quiet and before the soldiers are all inside, "you will see the labourers in motion, and hastening in various directions towards the breach, every one with a burthen of mortar in his mouth ready tempered. This they stick upon the breach as fast as they come up, and do it with so much dispatch and facility, that although there are thousands, and I may say millions, of them, they never stop or embarrass one another; and you are most agreeably deceived, when, after an apparent scene of hurry and confusion, a regular wall arises, gradually filling up the chasm." Other instances are given by this excellent observer in illus-

tration of the wonderful exactness of the division of labor in these insects. Smeathman well observes that "by the soldiers being so ready to run out upon the repetition of the attack, it appears that they but just withdraw out of sight, to leave room for the labourers to proceed without interruption in repairing the breach, and in this instance they shew more good sense than the bulk of mankind, for, in case of a conflagration in a city, the number of people who assemble to stare is much greater than of those who come to assist, and the former always interrupt and hinder the latter in their efforts. The sudden retreat of the labourers in case of an alarm, is also a wonderful instance of good order and discipline, seldom seen in populous cities, where we frequently find helpless people, women and children, without any ill intention, intermixing in violent tumults and dangerous riots."

Smeathman then speaks of the obstacles thrown in his way while examining the nests, by these intelligent creatures, in addition to the brittleness of the works inside. They fight to the very last, "disputing every inch of ground so well as often to drive away the negroes who are without shoes, and make white people bleed plentifully through their stockings. Neither can we let a building stand so as to get a view of the interior parts without interruption, for while the soldiers are defending the out-works, the labourers keep barricading all the way against us, stopping up the different galleries and passages which lead to the various apartments, particularly the royal chamber, all the entrances to which they fill up so artfully as not to let it be distinguishable while it remains moist."

How faithfully the queen is watched over by the laborers, who have so many other duties to perform, is very striking, and is a puzzling problem to those who would take the ground that these social insects are guided alone by blind instinct or an "unconscious automatism." Read Smeath-

man's account of their doings when the royal chamber is finally laid bare. He says that "these faithful subjects never abandon their charge even in the last distress; for whenever I took out the royal chamber, and as I often did, preserved it for some time in a large glass bowl, all the attendants continued running in one direction around the king and queen with the utmost solicitude, some of them stopping in every circuit at the head of the latter, as if to give her something. When they came to the extremity of the abdomen they took the eggs from her, and carried them away, and piled them carefully together in some part of the chamber, or in the bowl under or behind any pieces of broken clay which lay most convenient for the purpose."

It is the reserve mental power shown by these insects in rising to extraordinary occasions such as these that excites our astonishment. "Blind instinct" will serve for the performance of the most ordinary routine work of their social life, but even instinct is often at fault, and unless there is something in these beings akin to reasoning powers, one is at a loss to account for their readiness in dealing with unexpected emergencies, as seen in their manner of repairing their houses.

How insects came to be social is difficult to conjecture. The whole course of nature is opposed to concentrated effort on the part of animals. Nature from their birth scatters them. The few species of insects which are social are the exceptions to the rule, as the ancient civilizations of Assyria, Egypt, and America are phenomena, exceptions to the isolated tribes and families of savage peoples existing around them. The whole course of human progress tends to show that man at first lived in scattered families, which gradually assembled in scanty tribes, drawn together for mutual protection. At first the fact that colonies of insects exist so highly differentiated as the white ants, seems one of the most potent arguments against the development hypoth-

esis, but on reflection we cannot account for their origin without supposing that they have resulted through natural laws such as have acted in building up human societies. And the fact that there are all grades of complexity of social life among the Termites, down to species which are nearly solitary, almost on a par socially with other insects, shows that these clans, powerful from their superiority in numbers and intelligence, have been organized in consequence of pre-eminence in physical and mental qualities in the very face of the disorganizing forces of nature. This steady advance seen in certain lines of animal life, the degradation and retrogression in many others, show that there is something working through and above the ordinary laws of nature which evince Infinite Power and Will-force not of the world of matter.

Fritz Müller, who has observed the white ants of Brazil, has discovered that besides the four kinds of individuals first made known by Smeathman there are wingless males and females as well as winged ones, so that the complexity of the social life of these insects is still farther increased.

In a published letter to Mr. Darwin, he remarks: "For some years I have been engaged in studying the natural history of our Termites, of which I have had more than a dozen living species at my disposition. The several species differ much more in their habits and in their anatomy than is generally assumed. In most species there are two sets of neuters, viz., laborers and soldiers; but in some species (*Calotermes* Hag.) the laborers, and in others (*Anoplotermes*) the soldiers, are wanting. With respect to these neuters I have come to the same conclusion as that arrived at by Mr. Bates, viz., that, differently from what we see in social Hymenoptera, they are not modified imagos (sterile females), but modified larvæ, which undergo no further metamorphosis. This accounts for the fact first observed by Lespès, that both the sexes are represented among the sterile

(or so-called neuter) Termites. In some species of *Calotermes* the male soldiers may even externally be distinguished from the female ones. I have been able to confirm, in almost all our species, the fact already observed by Mr. Smeathman a century ago, but doubted by most subsequent writers, that in the company of the queen there lives always a king. The most interesting fact in the natural history of these curious insects is the existence of two forms of sexual individuals, in some (if not in all) of the species. Besides the winged males and females, which are produced in vast numbers, and which, leaving the termitary in large swarms, may intercross with those produced in other communities, there are wingless males and females which never leave the termitary where they are born, and which replace the winged males of females, whenever a community does not find in due time a true king or queen. Once I found a king (of a species of *Eutermes*) living in company with as many as thirty-one such complemental females, as they may be called, instead of with a single legitimate queen. Termites would, no doubt, save an extraordinary amount of labor if, instead of raising annually myriads of winged males and females, almost all of which (helpless creatures as they are) perish in the time of swarming without being able to find a new home, they raised solely a few wingless males and females, which, free from danger, might remain in their native termitary; and he who does not admit the paramount importance of intercrossing must, of course, wonder why this latter manner of reproduction (by wingless individuals) has not long since taken the place through natural selection of the production of winged males and females. But the wingless individuals would of course have to pair always with their near relatives, whilst by the swarming of the winged Termites a chance is given to them for the intercrossing of individuals not nearly related."

Among the ants the colony arises in the following manner.

The workers hibernate, rarely the females, and in spring take care of the eggs and larvæ produced the previous autumn. In the course of the summer the males and females appear, and late in summer on warm days they fly in the air in swarms. After the nuptial flight, the females may be seen running about on the ground biting their wings off. They enter the ground, sometimes the old holes, and lay their eggs and then die. The nests of some species of ants contain several thousand individuals. There are no species of true ants which construct such complex nests as the Termites, but in the sociability displayed by them, their love for their own kind and interest shown in other insects, they far surpass their prototypes, the white ants, and evince a psychological development that has a human element in it, which appears to be superior and superadded to the usual law of self-preservation and selfish instincts controlling the lower animals.

I shall not dwell on the ordinary life of the colony, as the history of the formicarium is given in entomological works. It may be observed, however, that the ants simply place their young in underground holes, not building cells for them as do the wasps and bees, and that the workers are undeveloped females, while in the Termites, the laborers are undeveloped individuals of both sexes.

We will now glance at some of the habits of ants which are the result of their living in crowded communities, but are not characteristics necessary for the preservation of each and every species.

One trait sometimes manifested in a prosperous and rich community of men is the oppression and enslavement of their weaker neighbors. So well-to-do, luxurious colonies of ants go on foraging expeditions, and each member of the party brings home in his jaws a sable ant. Our common red ant, *Formica sanguinea*, which builds high hills in the woods, is known to enslave a negro ant. How in one instance this operates on the captors is seen in the case of the *Polyergus*

rufescens, which is said by Mr. Frederic Smith to enslave four species of ants. These slave hunters are totally unable to perform their own labor, as they are incapacitated, as Latreille tells us, "on account of the form of their jaws, and the accessory parts of their mouth, either to prepare habitations for their family, to procure food or to feed them."

The sole motive, says Kirby, for their predatory excursions seems to be mere laziness and hatred of labor. They will not move or feed themselves. Huber shut up thirty of the slave-maker ants in a glazed box, supplying them with young of their own kind and honey. Many of them died of hunger and the rest seemed likely to, when he introduced a single negro, which restored order, making a cell in the earth in which it placed the young slave-holder brood and then saved the lives of the survivors.

Here we have two colonies united, each consisting of three sets of individuals, but the complicated work of the formicary goes on without any apparent disorder, such is the perfect division of labor. These Helots build or repair the common building, make excursions to collect food, attend upon the females, feed them and the larvæ, and if the weather be suitable, daily sun the eggs, larvæ and pupæ.

The love of acquisition, so common a trait with ants, as seen in their storing up seeds and enslaving other species, extends to the keeping of herds of cattle, namely, the docile Aphides, which receive the caresses of the ants and yield up their honey dew with true bovine meekness. Some underground Aphides live in ants' nests. The Aphides living primarily on the roots of vegetables, it is a question whether the ants excavate their nests around the root to which the Aphides are anchored by their long beaks, or whether they are introduced by the ants. These social creatures also go so far as to keep different sorts of beetles in their nests, either on the surface of the ant hill under stones, or down stairs in the basement of their dwellings. When alarmed

the ants may sometimes be seen running down their holes with these entomological poodles in their arms. If horses and dogs fraternize and institute Platonic loves, why should not the ants? Such patterns of all the domestic virtues have their pets. This is a bright side to the ordinary selfishness and utter absence of any moral attribute in these beings, and is a makeshift for goodness of heart which should draw out our sympathy towards these creatures.

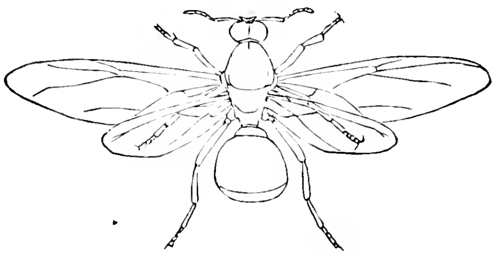
The ants work day and night, with occasional intervals of rest, and we are told by Kirby that they actually amuse themselves with sports and games. A colony of ants was observed by Bonnet enjoying the sunlight, one of their amusements consisting in their carrying each other on their backs, "the rider holding with his mandibles the neck of his horse, and embracing it closely with his legs." Huber also saw a numerous colony of *Formica rufa* at play. "I approached one day," he says, "one of their formicaries exposed to the sun and sheltered from the north. The ants were heaped together in great numbers, and seemed to enjoy the temperature which they experienced at the surface of the nest. None of them were working: this multitude of accumulated insects exhibited the appearance of a boiling fluid, upon which at first the eye could scarce fix itself without difficulty. But when I set myself to follow each ant separately, I saw them approach each other, moving their antennæ with astonishing rapidity; with their fore feet they patted lightly the cheeks of other ants; after these first gestures, which resembled caresses, they reared upon their hind legs by pairs, they wrestled together, they seized one another by a mandible, by a leg or an antenna; they then let go their hold to renew the attack; they fixed themselves to each other's trunk or abdomen, they embraced, they turned each other over, or lifted each other up by turns." He compares these sports, add Kirby and Spence, to the gambols of two puppies, and tells us that he not only

often observed them in this nest, but also in his artificial one.

Surely these ants exhibit nearly as much intellect as the monkeys and other animals, though perhaps not so intelligent as the domestic animals, which have been educated by their intercourse with man.

The *Œcodoma Mexicana* (Fig. 252, female) has two sorts of workers, the common one with a small head, and the

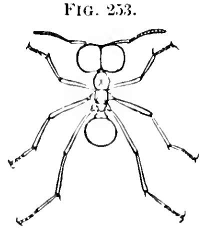
FIG. 252.



Female Œcodoma.

major workers, with enormous heads (Fig. 253). Sumichrast says that the intelligence of these ants is wonderful. They are seen in immense numbers transporting leaves to place in their nests, and this is done by the same principle of the division of labor so marked in the white ants. A part of these workers cut off the leaves, and others collect them and, carrying them off to their nests, march in long processions, each with a leaf over its shoulder like an umbrella, hence they are sometimes called "umbrella ants." Sumichrast says that "if the tree is not too lofty, one can satisfy himself that a party of foragers, which have climbed the tree, occupy themselves wholly in the labor of *cutting them off*, while at the foot of the tree are the *carriers*, which make the journeys between the tree and the nest."

FIG. 253.



Major worker Œcodoma.

Bates previously made similar statements regarding the Brazilian *Œcodoma cephalotes*. "They have," he says, "regular divisions of laborers, numbers mounting the trees and cutting off the leaves in irregularly rounded pieces the size of a shilling, another relay carrying them off as they fall." The large-headed individuals do not work, and are only to be seen on disturbing the nest.

An important part of the work in some ant colonies is the storing up of seeds. An East Indian ant (*Pheidole providens*) "collects so large a store of grass seeds as to last from January and February, the time of their ripening, till October.

We have in this country an agricultural ant, whose historian, the late Dr. Lincecum, of Texas, declares has the instinct to sow the grass from which the seeds are gathered by it. He is a reliable observer and studied this ant (*Myrmica molefaciens*) for a period of eighteen years. The assertion that the ants actually plant the grass may be confirmed or not by future observation. He makes the statement, however, that at the site of their nests, "there were little patches of the same grass scattered about on the little glade, which had doubtless been planted there by some experienced ant, for it had been neatly cleared of all other vegetables, in fact cultivated by them." He subsequently states in the same connection ("American Naturalist," vol. viii, 516) that "this species of ant subsists almost entirely on small seeds, great quantities of which it stores away in its granary-cells to supply food for winter. During rainy seasons in the autumnal months, it happens right often that the ground becoming saturated, the water penetrates their granaries and swells and sprouts their seeds. In this emergency they bring out the damaged grain the first fair day, and exposing it to the sun until near night, they take in all that is not actually sprouted. I saw them in G. W. Gentry's farm one day have out on a flat rock as much as a gallon of

wheat sunning. I wanted to see how they would manage to get so much back again, and returned again that evening just in time to see their hosts come out and carry it in in five minutes."

But Mr. Moggridge, the author of that entertaining book, "Harvesting Ants and Trap-door Spiders," has quite dispelled whatever doubts have arisen in the minds of modern naturalists respecting the frugal, provident habits of certain ants, fully proving the accuracy of Solomon's words, "Go to the ant, thou sluggard: consider her ways and be wise; which having no guide, overseer or ruler, provideth her meat in the summer and gathereth her food in the harvest." Again: "The ants are a people not strong, yet they prepare their meat in the summer." Our author also quotes Hesiod, Horace and Virgil as referring to this habit of the ants. But Ælian, who lived in the time of Hadrian, supplies full details. Moggridge quotes him as follows: "In summer time, after harvest, while the ears are being threshed, the ants pry about in troops around the threshing floors, leaving their homes and going singly, in pairs, or sometimes three together. They then select grains of wheat or barley, and go straight home by the way they came. Some go to collect, others to carry away the burden, and they avoid the way for one another with great politeness and consideration, especially the unburdened for the weight carriers. Now these excellent creatures, when they have returned home, and stored their granaries with wheat and barley, bore through each grain of seed in the middle; that which falls off in the process becomes a meal for the ants, and the remainder is unfertile. This these worthy housekeepers do, lest when the rains come, the seeds should sprout, as they would do if left entire, and thus the ants should come to want. So we see that the ants have good share in the gifts of nature, in this respect as well as others."

Northern observers have denied that ants lay up seeds.

Now two of these species of harvesting ants, noticed by Mr. Moggridge, inhabit France and Switzerland as well as Italy, but are not known to have this habit north of the Alps, so that it appeared probable to him, "that they do store in the south, but not in the north." Here we have one of the most striking cases on record of an entire change of habit in the same species in different climates.

One would think that the seeds stored up in this way would germinate, and be a source of trouble to the ants. They treat them, however, in such a way as to prevent their germination. Thousands of seeds from twenty-one nests were examined and only twenty-seven in seven nests showed traces of germination, though our author on removing the seeds from the granaries and planting them found that they readily grew. "When," he says, "the seeds do germinate in the nests, and it is my belief that they are usually softened and made to sprout before they are consumed by the ants, it is very curious to see how the growth is checked in its earliest stage, and how, after the radicle or fibril — the first growing root of dicotyledonous and monocotyledonous seeds — has been gnawed off, they are brought out from the nest and placed in the sun to dry, and then, after a sufficient exposure, carried below into the nest. The seeds are thus in effect malted, the starch being changed into sugar, and I have myself witnessed the avidity with which the contents of seeds thus treated are devoured by the ants."

While everything may go on harmoniously in one colony, ants are nevertheless extremely sensitive to the code of honor, and protracted duels take place between different colonies of the same species as well as of different species. Moggridge says that the most savage and prolonged contests which he has witnessed were those in which the combatants belonged to two different colonies of the same species. "*Atta barbara* will carry on the battle day after day and week after week. I was able to devote a good deal of time

to watching the progress of a predatory war of this kind waged by one nest of *barbara* against another, and which lasted for forty-six days, from January 18 to March 4!" These wars are usually the result of thieving expeditions.

This *Atta barbara* is said by Moggridge to drill holes in the rock, a fact not known to me until after the last chapter, on Insects as Architects, was printed. "In two cases," says our author, "I have found nests of *Atta barbara* at Mentone which were carried far into the living rock in places where it happened to be of an even grain, and not gritty or pebbly as it frequently is. It was quite by chance that I first discovered this very interesting fact, having tracked a train of seed-bearing workers to a part of the sandstone rock where steps had quite recently been hacked out leading to some terraces. . . . . . At one point, where the rock was almost entirely solid and without flaw or crevice, and where it was clear that the passages were entirely the work of the ants, we measured a tunnel by worming a straw down into it, and found it to be ten inches in length. He subsequently traced this tunnel or rock gallery down until it communicated with a chamber filled with winged ants and seeds of several kinds. This granary was horizontal, and merely an enlargement of an ordinary gallery of compressed spindle shape, flattened from above downwards, measuring as nearly as I could estimate three inches in length, by a trifle less than an inch in breadth, and half an inch in height. The walls were tolerably smooth, but not prepared or glazed in the way that certain small terminal cells which I shall shortly describe were."

Many more facts afforded by competent observers might be adduced to throw light on the interior life of these ant republics. How perfectly each one does the work allotted to it; how equally the division of labor is carried out; with what admirable harmony and unity of purpose all work for the common end, that end the preservation and maintenance

of the species, we have seen. The subject has by no means been exhausted. Over a thousand species of ants have been already described. The published observations relate to but a few of this legion of specific forms. In this country no observers have yet occurred, except Dr. Lincecum and Mr. J. A. Allen, who have published anything worthy of note on the habits of our native species. Here is a rich, unworked mine of knowledge which will afford the most interesting results to the younger naturalists of the country. When the good time comes, that millennium of American biological science, when all our species of animals shall have been classified, we shall hope for good work in the field of the observation of habits.

The wasps are both social and solitary. The latter build separate cells of sand or mud, sometimes placing several together. These cells are filled with the paralyzed bodies of caterpillars and other insects, and closed up. The young wasp begins life with a living supply of food at hand. The larvæ at least help themselves. Not so with the newly born young of the social wasps. They are daily fed by the parent or worker wasp.

Here we come again to insects, where a large part of the duties of the hive, those maternal cares only evinced in other insects by the mothers themselves, devolve upon a spinster race who have apparently all the labors and anxieties without the realities of maternity. What a strange phenomenon, this possession of the mental traits of the softer sex (if that term will apply to these insects, for the workers sting, while the males are harmless), without the power of transmitting them.

The simplest form of nest in the social wasps which we have in the United States are those of the Polistes, which consist of a number of cells attached by a common stalk to the branch of some bush, the entire nest being large enough to cover a third of one's hand, the cells being placed mouth

downwards. I have noticed in Virginia during the last week in April three species of Polistes beginning their nests, and working in the same manner. I never saw the nests at an earlier stage than when consisting of three cells, but it was easy to see that the first cell was only partially built before the other two were begun, and that virtually the wasp builds the three cells almost simultaneously. The outer edges of the incipient cells are said by Waterhouse to be perfectly circular, but at the time I saw them they were slightly angular on the outer edge, and by the time the cells are nearly completed the hexagonal form of the cells is attained. The wasp thus changes her plan of working, beginning to build them saucer-shaped, then cup-shaped, and finally forming them into deep hexagonal tubes. But one wasp, a female which has hibernated, builds a cell. Now this act of building the six-sided cell is in the wasps of the present day purely instinctive, but I firmly believe that when nature had the ancestors of these wasps in training, they built rude, solitary, more or less spherical cells, and only as the force of surrounding circumstances made them social, did they build more than one cell and put them together, when they were obliged partly by the necessity of mathematical laws, acting in a degree under the control of their reason, to build them in hexagons. There are social bees, such as the humble bees, in which the cells made by the larvæ are oval, though closely pressed together. Why do not they assume a hexagonal form if this is due simply to mechanical pressure? But look at the adult honey bee, or the Melipona or Trigona, which build hexagonal cells. They are not wholly the instruments of mechanical laws, but probably had in the earlier history of the species sufficient intellect to enable them to build their cells in hexagons. I am induced to take this view from seeing the wasp change its plan of building from a circular to a hexagonal one, as the cells grow higher and become more numerous. These crea-

tures are in a sense free agents, and are able to make a slight use of physical laws through the exercise of reason. It is probable that after thousands of generations these habits, at first slowly and painfully acquired, have become moulded into instincts, sometimes even nowadays at fault. For wasps and bees may make mistakes as well as men. My assertions would assume the form of arguments could I lay before the reader the multitudes of shapes in which wasps and bees build their nests. The gradations from the simple nests of the solitary wasps up to the complicated, enormous nests of some species of Vespa are manifold, and are evidences that their different styles of architecture are outgrowths of a single, simple spherical cell, each kind differing according to the intellectual traits of its builder and the peculiar exigencies of its life.

The cells of these wasps, though for the most part constructed of bits of wood and the bark of trees gnawed off by the wasp, are in their earliest stages largely composed of silk secreted in the salivary glands of the wasp. Perhaps chewing this woody matter promotes a freer flow of the secretion. At any rate the silk is plastered on thickly by the wasp. She is very careful to have the common pedicel, by which the cells are suspended, of great strength; it must therefore consist almost entirely of silk. I have watched a Polistes by the hour, plastering the pedicel with silk, going over it with its tongue, and proving its work with its sensitive antennæ, which rapidly patted the work as if they were fingers.

By the time three cells are perhaps one-half made, the wasp lays an egg at the bottom of two of them; by the time the fifth cell is partly completed, the four others each contain an egg. As the cells increase in number through the industry of the parent, more eggs are laid. The young hatch from the eggs first laid, and now the duties of the parent wasp are doubled. She feeds the young with flies

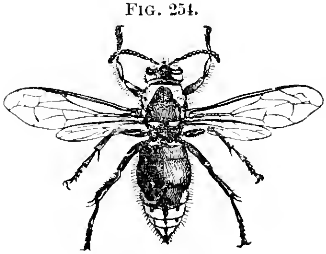
and other insects, often aiding the butcher by flying off with the blow-flies that spoil his meat. Here is a field for the exercise of the wasp's reasoning powers, impelled and guided as they are by her primary parental instincts. It is in the minor doings, the accidents of life, so to speak, that their reasoning powers are brought into action. Most of mankind live by their instincts rather than their reason. They labor in the same fashion as their grandfathers, as for instance in farming, men till the ground in the same fashion as their fore-fathers, and when quick-witted persons, those who use their perceptive and reasoning faculties, endeavor to improve upon the customs of the olden time, everybody knows how hard it is to have them changed. Their primitive mode of farming, from becoming habitual, becomes instinctive, and often nothing but the love of money, the selfish principle, stronger in some men than the love of their kind, gets them out of the ruts, when from being *quasi* creatures of a blind instinct, unconscious automata, they with others aid in the advancement of their race. So there are philosophers and reformers who do the thinking for the masses. And something of this kind must go on in the animal world or there never would have been progress upwards in the animal scale. Some new exigency, due to a change in their physical environment, arises, when a new line of action is begun, resulting in a new set of habits, new instincts and new species, the physical embodiments of the novel intellectual qualities characterizing the new creations.

In about a month a brood of workers appear. They at once aid the old queen in building more cells, and now the nests increase more rapidly in size. The material for them is mostly taken by the workers from the bark of trees or the palings of fences, the wasp gnawing them off with her large heavy jaws. In this way the great hornets, within the last ten or fifteen years in the vicinity of New York, have actually scraped off the bark of lilacs so as to disfigure them.

But nature has prohibited them from rearing offspring of their own. They feed the young, and watch over them until a new brood appears late in the summer. The family circle is now completed. A few females and males appear, and linger on until the early frosts of autumn kill the latter, when their wives take shelter under leaves or in cracks under the bark of trees, there to await the warmer days of spring.

The paper making wasps, various species of Vespa, as soon as a tier of cells is partially built, begin to build out a wall of paper from near the base of the pedicel. This grows more and more as the cells increase in number; when, arranged in several tiers supported by pedicels, they are completely walled in by the intelligent wasps. The nests of the common wasp which builds about houses are seldom larger than one's fist, but the nests of the *Vespa maculata* (Fig. 254) are twice as large as one's head.

FIG. 254.



Vespa maculata.

All wasps are not makers of paper. The oriental wasp (*Vespa orientalis*) builds its cells of clay, and according to Waterhouse, "the work is exceedingly beautiful and true." Another species, says Mr. Frederic Smith, of the British Museum, "makes its nest of sandy loam, the exterior being so hard that a saw used in opening one of its sides was blunted."

Among the social wasps there are two series, and it is difficult to say which is the higher; in fact, the Hymenoptera as a group may be compared to a tree, the topmost branches, no one more preëminent than the others, representing the social species. The ants are fully as intelligent, their social life as fully, if not more, complex than that of the wasps or

bees. We may say that there is a parallelism in the intellectual life as well as physical forms of these insects.

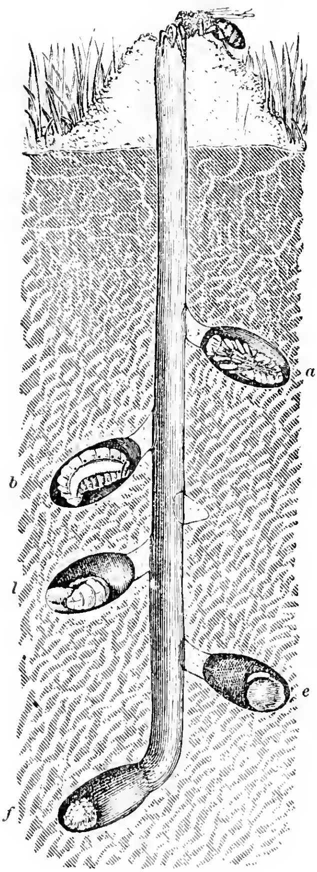
In the tropics there are social wasps with exceedingly numerous colonies. Such is the Nectarina, a plump-bodied wasp, which in Mexico builds a large nest, externally like that of a wasp, but more irregular, and with the walls consisting of but a single layer. The interior of the nest is very different, the galleries of cells, instead of being parallel, being arranged in concentric spheres. The *papier-maché* wasp, as we may call it, or *Chartergus chartarius*, makes a nest of the consistency of the densest pasteboard, which is attached by a broad base to the bough of a tree, and is about twice as long as thick, ending in a cone in which is the entrance, from which is a passage from the middle to the basal gallery, while the other galleries are formed by a continuation of the sides of the nest, and arranged in a conical plane.

The *Tatua morio* of Cayenne builds a nest somewhat like that of the *papier-maché* wasp, but the galleries form a flat floor, and each gallery has a separate entrance from the outside of the nest. The nest of the social *Synæca cyanea* is formed by a single layer of cells fixed against the trunk of a tree, and protected by a dense covering made from the bark of dead trees, some nests being three feet long. There are numerous less social species belonging to the genera Apoïca, Icaria, etc., which build uncovered nests of but few cells, but those distinctly hexagonal; these form a connecting link between the populous nests we have just described and the solitary mud cells of the Odynerus and Eumenes.

Turning now to the bees, we find an attempt at sociability in the nests of the *Andrena vicina*, a common bee in the northern states, which may best be described by saying that it is of the size and general appearance of the honey bee. Mr. Emerton has observed its habits quite closely and made the accompanying drawing of its cells. The nest may be

detected by its resemblance to an ant's nest, as the bee in burrowing throws up a small hillock of sand. First she burrows straight down for two or three inches, and then, turning off a little, forms a cell as at *a* (Fig. 255), where she deposits a mass of pollen as large as a pea and lays an egg upon it. By the time this has hatched and the larva has passed into its pupal sleep as at *a*, several other cells have been excavated, the lowest one, of course, being the most recent. In the figure the lowest cell (*f*) contains only the freshly laid pollen cell; at *e*, an egg is represented as laid by the bee on the upper surface of the mass; while the partly grown larva is represented at *l* lying on its side devouring the pollen, which has, as seen at *b*, been eaten up, the grub now being fully grown and ready to pass into the pupa state.

FIG. 255.



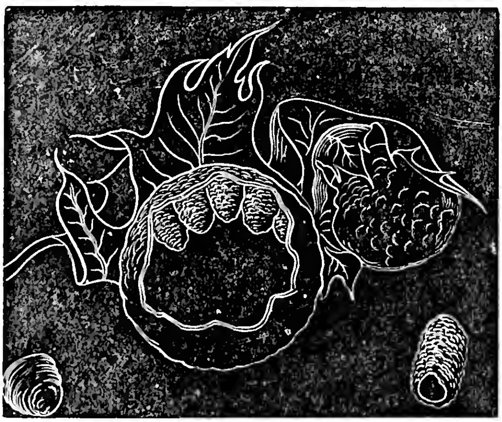
Andrena vicina.

The little mason bee may be said to be social in some degree. She builds her urn-shaped earthen cells of clay or fine mud in tunnels or holes, sometimes in empty snail shells. The little green *Osmia simillima*, our commonest species of mason bee, sometimes places four or five of her clay cells in deserted galls, as in Fig. 256.

The leaf cutter or tailor bee is also partly social, in so far that it makes a number of cells and places them close together in the hollow of the branch or stalk of some pithy plant, such as the elder, but like the Andrena and mason bee there is no combination of two or more individuals as in the truly social wasps and bees. The leaf-cutter bee sometimes builds as many as thirty cells, arranged end to end. Usually, however, but a few cells are made. Fig. 257 represents three such cells in the stem of an elder stalk.

I am not aware that there is any other bee which at all

FIG. 256.



Cells of Mason Bee in a gall.

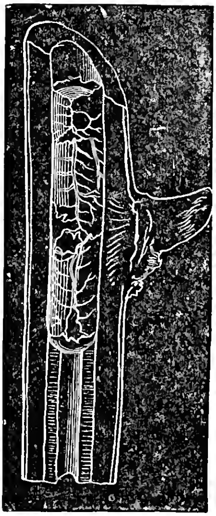
approaches the tailor bee in the unique habit of cutting out circles from rose leaves and so adjusting them as to form a cartridge like cylinder. Fig. 258 represents the bee in the act of cutting out these circles. The act is as deliberate and methodical as that of the Attelabus, the weevil which so carefully cuts and rolls up the leaf into a solid cartridge-like mass in which to deposit its eggs. It also invariably, so far as I am aware, selects the rose. A single bee in one instance, as observed by Mr. F. W. Putnam, cut out at least

a thousand such leaves with which to construct her cells. The cell is filled with pollen and an egg is deposited on the mass, before it is finally closed.

Another species of Megachile (*M. brevis*) in Canada, according to Mr. E. B. Reed, cuts circular pieces from the leaves of the plum tree, and also rolls up the leaves of the tree as a covering for its nest.

Mr. W. M. Davis, Jr., tells me that he has observed a leaf cutter bee cutting pieces out of the leaves of the sassafras, and during his residence in Cordoba, South America, he found several nests of a Megachile in a bank, the cells of which were formed of the yellow petals of a species of poppy.

FIG. 257.



Cells of Leaf Cutter Bee.

In India, besides certain species of Megachile which build cells of rose leaves, one species (*M. proxima*) cuts the leaves of the Clitoria creeper; there are others which form them of mud. According to Messrs. Horne and Smith the *Megachile lanata* builds in different objects within or about houses. Both sexes appear to labor. The mud is carried under the head and in part supported by the fore legs, and these authors believe that "when the clay, having been first prepared at the water, is brought into use, it is inspissated with some glutinous substance ejected by the insect. It is certainly very carefully kneaded again by many of the clay-cell-builders." The *Megachile disjuncta* has the same habits as the Woolly Megachile.

A large proportion of the wild bees' nest in the ground like the Andrena; a few bees, like the cuckoo, live a parasitic life in the cells of other bees. It is not well understood what their young feed on, but it seems most probable that

they do not attack the larvæ of their hosts, but steal their bee-bread.

The bumble or humble bee is truly social, and yet in a manner quite its own. Besides the males and queens, there are a large number of workers, but they do not assist in building any cells, as the larvæ in part make their own cells. The habits of the humble bees in this country have been studied with much attention by Mr. Putnam. He shows by independent observation that the queen which has hibernated, after selecting a site for her nest in an abandoned mouse's-nest or stump, collects a small mass of pollen mixed with honey, and in this deposits from seven to fourteen eggs, gradually adding to the pollen mass until the first brood is hatched. Now it seems that as soon as the grubs begin to eat they make cavities in the mass, and when fully grown spin an oval cocoon about them. Thus the act of building these oval cells is a purely mechanical one. These grubs are in truth unconscious automata. They, however, are in a degree aided by the queen, who strengthens the thin walls of the cell by covering them with a thin layer of wax. The cells form an irregular mass, but however thickly crowded together always retain their oval form (Fig. 259, 2, showing eggs laid in a pollen mass on one end of a cell). It is this fact which leads us to believe that the wasp or honey bee in building its six-sided cells, did so in the beginning from design, however instinctive the act now is, and that they are not compelled to do so unconsciously and in obedience to certain laws of mechanics which they are forced to follow.

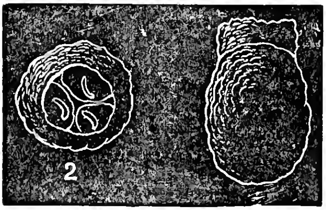
FIG. 258.

Leaf Cutter Bee at work.

The mechanical theory of the formation of the bee's cell

has been most ably advocated by the Rev. Samuel Haughton. His view is that the hexagonal form of the cell "may be accounted for simply by the mechanical pressure of the insects against each other during the formation of the cell. In consequence of the instinct that compels them to work with reference to a plane, and of the cylindrical form of the insect's body, the cells must be hexagonal." Now, this view would scarcely apply to the hexagonal cells of the wasp's nests at the period when only three cells have been made, and a single wasp is the builder; nor to the nest of *Icaria guttatipennis*,* where six cells are arranged in a single row and attached to a branch by a slender stalk at one end of the row. In this instance also there is no crowding together of several individuals working simultaneously, but a solitary wasp freely building her hexagonal cells without being subject to mechanical constraint.

FIG. 259.



Cells of Humble Bee.

If there was not the agency of mind in the operation superadded to the reproductive instinct which primarily impels all the insect world to action, we should never have had an advance beyond the humble bee stage. So among the wasps; if they had always solely lived on the principle of each one providing for itself, if the reproductive and selfish instincts alone held sway, we should never have seen wasps building cells in common, under a common shelter, and working together for the common good of all. The whole course of nature tends to establish the fact that in the early history of the sport or variety which gave rise to the species as we now find it, some bees more quick-witted than others struck out in new directions, took a step in advance of their fellows,

* See the figure in my "Guide to the Study of Insects," Pl. 5, Fig. 7.

and hit on a plan of building which proved advantageous to the species, when Nature stamped her approval of the reform by preserving the species in the condition we now behold.

When the workers appear they aid in bringing home supplies of pollen and honey, but do not build, and in fact the humble bee is not much of an architect.

In the stingless bees (Melipona and Trigona) of the tropics, however, we have a high degree of architectural skill shown in the construction of their cells. The domestic Melipona of Mexico constructs combs of hexagonal cells smaller though like those of the honey bee, but they also have large irregular roundish cells an inch in diameter, which serve as honey pots. According to Fritz Müller, who has observed these bees in southern Brazil, the wax is secreted on the upper side of the abdomen, instead of the under, as in the hive bee. The wax is usually dark-colored, but susceptible of bleaching. He also states that while the larvæ of the honey bee are fed by the laborers at first with semi-digested food, and afterwards with a mixture of pollen and honey, and while the cells are closed only where the larvæ are full-grown, "the Meliponæ and Trigonæ, on the contrary, fill the cells with semi-digested food before the eggs are laid, and they shut the cells immediately after the queen has dropped an egg on the food. With hive-bees the royal cells, in which the future queens have to be raised, differ in their direction from the other cells; this is not the case with Melipona and Trigona, where all the cells are vertical, with their orifices turned upward, forming horizontal (or rarely spirally ascending) combs."

The colonies of these bees are exceedingly populous, the workers being numbered by the thousands. Smith says that "Mr. Stretch, who lived at Panama, described a hive that he saw, occupying the interior of a decaying tree, that measured six feet in length, and the multitude of bees he compared to a black cloud." This colony belonged to a species

of Trigona. Both this and Melipona are supposed to have more than one queen in a colony.

The mode of nesting in these bees is very unlike in different species. "Many species build in the hollow trunks of trees, others in banks; some suspend their nests from branches of trees, whilst one species constructs its nest of clay, it being of large size." (Gardner.)

It is but a step from the stingless bees to the hive bee and the wild species, of which there are at least five. The economy of the hive bee is so well known that I shall here only notice some of the habits of the wild species of the East Indies, the home of all the species of Apis.

Wallace says that "true honey-bees are found in the western half of the Archipelago, and in the southeast as far as Timor, where, however, it is possible that they may have been introduced. *Apis dorsata* and *A. testacea* both construct large combs suspended from the underside of the branches of lofty forest-trees. They sting very severely; yet the natives ascend the trees, and with nearly naked bodies take away the combs, protected only by a smouldering torch, the smoke from which in some degree keeps off the insects. The Dyaks of Borneo ascend the trees by driving strong pegs of bamboo into the trunk, which they connect with an upright bamboo, and thus form a good ladder. The people of Timor literally walk up tne trees, by means of a long piece of creeper put round them, and the extremities held in the hand. It is a wonderful sight to see a man ascend thus a vertical trunk one hundred feet high, and then creep out upon a horizontal branch and coolly brush away the myriads of bees from a comb a yard in diameter, and become immediately enveloped in a cloud of angry insects, while he cuts off the comb and lets it down to his companions below by a slender cord. In this manner many tons of wax are annually collected, the immature bees and honey supplying a luxurious feast to the bee-hunters."

How the domestic hive-bee builds its cells has been discussed by Mr. Darwin in the "Origin of Species." His theory seems to combine the purely mechanical views of Haughton and Waterhouse, with the view that the bee unconsciously takes advantage of modifications of simple, primitive architectural instincts such as many other insects possess. If I understand his theory aright it implies that the bee, by the very act of "taking advantage" of the simple instincts, must in the nature of the case act as an intelligent agent. He thus sums up the leading points in his theory: "Thus, as I believe, the most wonderful of all known instincts, that of the hive-bee, can be explained by natural selection having taken advantage of numerous, successive slight modifications of simpler instincts; natural selection having, by slow degrees, more and more perfectly led the bees to sweep equal spheres at a given distance from each other in a double layer, and to build up and excavate the wax along the planes of intersection; the bees, of course, no more knowing that they swept their spheres at one particular distance from each other, than they know what are the several angles of the hexagonal prisms and of the basal rhombic plates; the motive power of the process of natural selection having been the construction of cells of due strength, and of the proper size and shape for the larvæ, this being effected with the greatest possible economy of labor and wax; that individual swarm which thus made the best cells with least labor, and least waste of honey in the secretion of wax, having succeeded best, and having transmitted by inheritance their newly acquired economical instincts to new swarms, which in their turn will have had the best chance of succeeding in the struggle for existence."

Mr. Darwin has noticed the objection to such a theory in the fact that bees have a capacity of "laying down under certain circumstances a rough wall in its proper place between two just-commenced cells" which is important, "as it

bears on a fact, which seems at first quite subversive of the foregoing theory; namely, that the cells on the extreme margin of wasps-combs are sometimes strictly hexagonal. This seems to me, as already stated in the "Guide to the Study of Insects," a fatal objection to any purely mechanical theory, and I cannot but regard the method of building in hexagons as demanding, in the first bee which built its cells in this fashion, as much reasoning power as the beaver exerts in planning its dams; and who will affirm, after reading Mr. Morgan's work on the beaver, that this animal is guided purely by a blind instinct, or is an unconscious machine?

13. Mental Powers of Insects.

IT is almost invariably the case that those who have closely observed and recorded the habits of animals, nearly always express their surprise at the high degree of intelligence exhibited by them, and do not hesitate to state their opinion that animals are provided with some degree of reasoning power; while others, still more confident, declare that this intelligence differs only in degree from that of man himself. The works of DeGeer, Réaumur, Huber, Bonnet, and of later eminent observers of the habits of insects, express the view that they exhibit more or less of a reasoning power.

On the other hand there are many, generally those who have not personally observed the doings of animals, and are biassed by considerations to which it is needless here to allude, who are very strong in the faith, for it is not with them a matter of observation or experiment, that animals act simply by "blind instinct," that they are machines, automata. When asked how animals sometimes act in a manner so akin to that of man, the only reasoning being, according to their view, in existence, they answer that they are taught by Divine Power. This with them is the end of the matter, except that they seem indignant that any lower animal should for a moment be regarded as in any way allied to themselves; as if the intellectual and moral standing of man is at all compromised by allowing that the animals possess intelligence, and at periods act as if influenced by reason.

We have no controversy with those who believe that the instincts of animals have been implanted by the Creator, as we are of the same opinion. The question simply is,

what is the kind of mind possessed by animals; have they a slight degree of reasoning power; are they in some degree free agents? And how did the instincts, which all agree they possess, originate? We shall attempt to answer these questions, speaking on this occasion simply in behalf of the insects. As to the domestic animals, the horse, dog and others, which by association with man have undergone a certain amount of education, there are few people exercising their perceptive and reasoning faculties, who do not ascribe to these animals a degree of reasoning power, which they do not confound with their ordinary instinctive acts.

Confining our attention to the insects, let us in an unprejudiced way examine this matter and ascertain what faculties resembling those of man they possess. Our conclusions will have a degree of uncertainty, and be based mainly on probability, so that there is little occasion for dogmatism. Our space is not extended, and in laboring to be brief we may seem, but not intentionally, to be dogmatic.

Those who observe the ways of insects have noticed their extreme sensitiveness to external impressions; that their motions are ordinarily rapid and nervous. Look at the ichneumon fly as it alights on a leaf near a caterpillar. With what rapid motions it walks and flies about; how swiftly its feelers vibrate, how briskly it walks up and down surveying its victim. Look at a mud wasp as it alights near a pool of water to moisten its mouth. How nervous are its motions, how nimbly it flies and runs about the edge of the water. The ant is a busy, active, dapper little creature, a nervous brusqueness pervading its movements. How susceptible insects are to the light may be tested on a damp, dark night by opening the windows. In dart a legion of insects of all sorts, each with a different mode of entrance, some beetle boldly flying about the room in its blundering, noisy flight, or a Clisiocampa moth enters with a bound and series of somersaults over the table like the *entrée* of a popular clown into the

ring of a circus, though the latter may have the most self-possession of the two.

In his "Observations on Bees and Wasps," Sir John Lubbock says that "though bees do not come out at night, they seem to be much affected by light. One evening I lit a small covered lamp to go down to the cellar. A bee which was out came to it, and, flying round and round like a moth, followed me the whole of the way there."

Insects are, like most animals, extremely sensitive to electrical phenomena. Just before a thunder shower they are particularly restless, flying about in great numbers and without any apparent object. The appendages of insects, their feelers and their legs, must be provided with exquisitely sensitive organs to enable them to receive impressions from without.

Everybody knows that insects have acute powers of sight. That they also hear acutely is a matter of frequent observation. Often in walking through dry bushes the noise of one's feet in crushing through the undergrowth, starts up hosts of moths, disturbed in their noonday repose. If insects did not hear acutely, why should the Cicada have such a shrill cry? For whose ears is the song of the cricket designed unless for those of some other cricket? All the songs, the cries and hum of insect life have their purpose in nature and are useless unless they warn off or attract some other insect.

We know with a good degree of certainty that some insects have an acute sense of smell. The carrion beetles scent their booty afar off; the ants, the moths, all the insects attracted to flowers by the smell of the honey in them, evidently have well developed organs of smell.

Insects evidently have, like man, perceptive faculties. Let us now examine the organs of sense and the nervous system of insects, and thus approach the subject of the instinctive and reasoning powers of these animals from the side of anatomy and physiology.

Fig. 260, copied from a drawing by Prof. Leidy, represents the nervous system of a neuropterous insect, the Corydalus, figured on page 151. The central nervous system is a double cord enlarged at intervals, forming nerve centres or *ganglia*, of which there are sometimes thirteen pairs. A Russian anatomist, Offsiannikoff, has found that the ganglion of a spiny lobster (*Palinurus*) is composed of nucleated cells, from which arise very long fibres which are gathered into bundles, forming the nerves ramifying throughout the body. There is thus a direct physical communication, telegraphic wires, as it were, leading from all parts of the body to these nerve-centres. Of these there are two pairs lodged in the head; the most anterior, those situated in the top of the head, are the larger and are for convenience called the brain, but it will be seen, that though they are a little larger they do not differ from the other pairs of nerve centres. From this so-called brain are distributed nerves to the antennæ, the palpi and jaws; a large thick nerve sent to the eye is the optic nerve (*a*).

FIG. 260.

Nervous System of Corydalus.

From the other nerve-centres filaments are thrown out to the wings, legs, muscles and vessels in the body. We shall see that these centres are really so many brains, and that insects differ in this respect from the vertebrate animals in

which there is a true brain or mass of ganglia lodged in the skull or brain-box; though it may be added that the spinal cord is in a degree a nervous centre in itself.

The large eyes of insects are made up of a great number of simple eyes, the optic fibres from each one of these simple eyes (indicated externally by facets) uniting to form a common nerve connecting with the brain. How large may be sometimes the number of simple eyes united to form this composite eye is seen in a certain butterfly which has 17,355 of them. The eye of the dragon fly consists of 12,544, while the eye of the common house fly has 4,000 facets, or corneæ. In these insects the composite eyes are exceedingly large, sometimes, as in the house fly or dragon fly, forming the greater part of the bulk of the head. There is every reason, from the complicated structure of the eye, which we will not here describe, and from the movements of these insects, to infer that they have acute powers of sight. Even certain low insects and the young of the higher ones, in which the eyes are rudimentary and single, have, it is known from experiment, the power of distinguishing light from darkness, a matter of considerable importance to these insects, which mostly move about at night.

While the eyes in insects are invariably situated on the head, this is not the case with a large number of little sense organs which are found in the antennæ and the palpi or feelers, attached to the accessory jaws (maxillæ) and the under lip (labium).

These minute organs consist of a little cavity, covered by a membrane, which is supposed to act as a tympanum. In connection with the cavity is a nerve which runs to a ganglion. When there are a number of these microscopic sense organs placed together, the nerves proceeding from them unite to form a common fibre, as in the antennal nerve. This sense apparatus is supposed to be usually auditory in its function, as it is in some form or other almost invariably

found in the antennæ. Similar organs also occur at the end of the palpi. I have found a similar isolated sac on the under side of both the labial and maxillary palpi of a Perla (Fig. 99). It is probable that this is an olfactory organ, and placed on the under side of the feeler, next to the mouth, so as to enable the insect to select its proper food by its odor, giving an additional sensory function to the palpi of insects, which are supposed to be organs of touch.

In the blow fly there are a number of these organs situated at the base of the wings and near the spiracles or breathing holes. Similar organs are found in the wings of the carrion beetles and are supposed to be olfactory in their function.

There are also sense organs, probably ears, on the fore legs of certain species of grasshoppers. Sense organs even occur in the jointed appendages of the hind body or abdomen. Our attention was first called to this fact by the discovery by Dr. Dohrn of sense organs in the jointed appendages of the mole cricket. Stimulated by this I examined the long, slender, jointed feelers of the cockroach, and to my great joy found ninety-five of these little pits on one, and one hundred and two on the other. It is evident that the creature is provided with a double set of antennæ, one on the head and another on the tail. True abdominal antennæ seem also to occur on the abdomen of the Mantis.

I have also found sense organs similar in appearance on the abdominal appendages of a fly (Chrysopila), and it is not improbable that these organs will be found in similar situations in other insects. They are thus scattered at random, as it were, over the surface of the body. No wonder that insects are so alive to impressions from without!

Without much doubt the nerves distributed to these organs are nerves of special sense, and as the ganglia from which they arise may be situated near the end of the abdomen or in the thorax as well as in the head, it appears that

this chain of ganglia is really a series of brains, so that if insects think at all the process is carried on in the abdomen as well as the trunk or the head!

This accounts for the fact that when insects are deprived of their head, or abdomen, they will sometimes continue to live for many hours. They still have a few pairs of brains left. So also when the sand wasp stings the caterpillar or spider in the thorax its whole body is paralyzed. Probably the brain proper is never injured, as the sting is not known to penetrate the head.

The hairs of insects found scattered over the body, particularly those on the feelers and the more exposed parts of the body, are often provided with a nerve, and are exceedingly delicate tactile organs. Mr. R. Beck "suggests that spiders are capable of distinguishing sounds to some extent by means of very delicate waving hairs, which are found on the upper surfaces of their legs. During life they move at their peculiarly cup-shaped bases, with the least motion of the atmosphere, but are immovable after death. It is well known that sound is due to vibrations which are generally conveyed by undulations of the air; now I am perfectly satisfied that if these undulations are of a certain character the hairs I am alluding to, upon the spider's leg, will move, and I wish you particularly to notice that they are of different lengths, so that some might move whilst others would not, and also that the longest is at the extremity of the leg, and therefore can receive an undulation which might die away higher up. I may thus mention that there is a group of these peculiar hairs on the flea. The legs of a spider are most sensitive organs of feeling, if they do not also embrace those of hearing." The reader is by this statement reminded of the interesting discovery of Dr. Johnson, confirmed and extended by Professor A. M. Mayer, regarding the sense of hearing in the mosquito, which we have already referred to in a previous chapter.

We have endeavored to establish the fact that insects are extremely sensitive to impressions made by external objects upon the senses. Using the language of the mental philosophers, who divide the human mind into the sensibilities, the will, and the intellect, any one will grant that insects are certainly endowed with sensibilities, the first subdivision of the intellect.

Having perceived an object, or received an impression on its organs of smell or hearing, such as the odor of decayed carrion or of a flower, the carrion beetle or bee immediately flies to the object. How strong impulses arise from this acuteness of the sense of smell in the carrion beetle is shown by the following fact mentioned by Kirby and Spence. "A German naturalist, Gleditsch, relates that he one day spitted a toad on a stick, which he fixed upright in the ground. A number of burying beetles (*Necrophorus vespillo*) came around it; but as they could do nothing with the toad while in the air, they mined under the base of the stick till it fell, and then buried toad and stick together." Some insects are found in the flowers of plants which have the smell of carrion, and frequent no other plants. Here is certainly a power of choice, an act of volition; the insect rejects pleasant smelling flowers for bad smelling ones. This act involves, however, not only powers of the will, but of the intellect also, as the very fact of its making a choice proves that different odors affect it, and that it selects a certain odor in preference to another. The flesh fly has been known to be so misled by the odor of bad smelling plants that it has laid its eggs in the flowers of *Stapelia hirsuta* instead of carrion. (Kirby and Spence.)

If any one should have the hardihood to deny that insects exercise powers of volition, that in other words, they do not follow the lead of their senses, acute as we now know they are, let him catch an humble bee between his fingers, and see if the creature hesitates to use its sting. He will very soon

realize that the bee has a will of its own and that her will acts with a promptness and decision which at once appeals to the sensibilities of the experimenter. But bees sometimes attack persons whom they seem to dislike, or cluster as it were lovingly about one for whom they have some sort of regard. Is not this an act of volition, of the exercise of a will, added to an operation of the intellect?

In illustration of this power of discrimination between their friends and enemies, I borrow the following anecdote from the Rev. J. S. Watson's work on the "Reasoning Power of Animals."

"It may well be considered an indication of reason in bees that they know, as is confidently asserted, their master, or the person who chiefly attends to them. A singular statement to this effect is given in Stedman's 'Voyage to Surinam.' I was visited at my hut, says Mr. Stedman, whose words I abridge, by a neighboring gentleman, who had no sooner entered, than he leaped out again, roaring like a madman with pain, and ran off to the river to plunge his head into the water. The cause of his distress, was, that, being a tall fellow, he had struck his head against a large nest of wild bees which had built in the thatch. I, apprehensive of a similar attack, withdrew immediately from the hut, and ordered the slaves to demolish the bees' nest without delay. They were just going to do so, when an old negro came up, and declared that the bees would never sting me personally, offering to undergo any punishment if one of them ever did so. 'Massa,' said the negro, 'they would have stung you long ago, had you been a stranger to them, but, being your tenant, and allowed to build upon your premises, they know both you and yours, and will never hurt either you or them.' This Mr. Stedman found to be the case, for even after shaking the nest, the bees would sting neither him nor his negroes. The same old negro told Mr. Stedman that he had lived on an estate on which there was

a large tree, in which there had been, as long as he could remember, a society of birds, and another of bees, living together in the greatest amity; for if any strange birds molested the bees, the birds on the spot drove them off in a body; and if strange bees came near the birds' nests, the native bees attacked them and stung them to death. The family of the owner, he said, had so much regard for the harmonious colonies, that they considered the tree sacred."

Aside from mere physical stimulation, such as the reception and appreciation of sounds, smells and changes from light to darkness, to which nearly all insects are subject, close observers have told us that insects sometimes give every appearance of being subject to the passions. They not only have strong reproductive instincts, but undoubtedly a hungry tiger beetle is a very cross creature, a maddened ant is a terror to a barefoot boy who treads carelessly on its hill, and a terrified or angry humble bee buzzes with an intensity that proves that it has suffered a considerable shock to its feelings. That bees do become angry is indicated by a different pitch to their hum. "Landois, calculating the rapidity of the vibrations by the sound produced thereby, states that the fly, which produces the sound of F, vibrates its wings 352 times a second, and the bee, which makes the sound of A′, 440 times a second." On the contrary a tired bee hums on E′, and therefore vibrates its wing only 330 times in a second. This difference is probably involuntary, but the change of 'tone' is evidently under the command of the will, and thus offers another point of similarity to a true 'voice.' A bee in the pursuit of honey hums continually and contentedly on A′, but if it is excited or angry it produces a very different note. Thus, then, the sounds of insects do not merely serve to bring the sexes together; they are not merely 'love songs' but also serve, like any true language, to express the feelings." (Sir John Lubbock's address

before the London Entomological Society, 1868.) But besides all this we know that ants engage in sports, that they wrestle and toss each other about in a playful way, as evidently so as that young dogs or cats play with one another. Insects of all animals, must experience pleasure or pain in accordance with extremes of cold or heat. They play only when stimulated by the rays of a hot sun.

Bees, as Lubbock observes, have a variable temper. "Generally they allowed me to handle them without any sign of irritation; while at other times, without any reason which I could discover, they stung me sometimes several times in a day; they seemed the more prone to do so the hotter the weather."

If it were not for their sensitiveness to pleasure and pain, the instinct of self-preservation, so powerful with animals, and which would cease to operate unless their will-force was strongly developed, would cease to be exerted. Kant's expression,* "Pleasure is the feeling of the furtherance, pain of the hindrance of life," applies to insects as well as men. The fact that insects must at times enjoy a warm sunny day, that they have what we call animal spirits, is a proof that they have not only feelings and will, but possess intelligence and, possibly, in a slight degree self-consciousness.

Having seen that insects have acute sensibilities, that they see, hear, smell and feel with sufficient acuteness to enable them to maintain their existence, we have the foundations laid by which their will may operate. That insects have a certain amount of will-force, that they can act with energy and decision when their feelings are shocked, that when pleasurable sensations arise they indulge those emotions for a longer or shorter time, seems to be susceptible of proof.

Now granted that insects have sensibilities and will, how

* Quoted by Mr. Bain in his "Mind and Body," Appleton's International Scientific Series.

are we to prove that they have an intellect? Simply by observing whether they make a choice between two acts.

On entering a closet, ants unhesitatingly direct their steps to the sugar bowl in preference to the flour barrel; one sand wasp prefers beetle grubs to caterpillars to store up as food for her young. In short, insects exercise discrimination, and this is the simplest of intellectual acts. They try this or that method of attaining an object. In fact, an insect's life is filled out with a round of trials and failures. That they have the quality of perseverance in a high degree is proved by the statements of many observers. In building her nest how many unsuccessful attempts the spider often makes before she finally succeeds in properly fastening her threads, the frame work of her web. Robert Bruce is said to have admired the perseverance of a spider after repeated failures; indeed, the persevering labors of the ant, the bee, or the fly are matters of daily observation.

As an illustration of the perseverance shown by ants combined with the faculty of the communication of ideas which they possess to such a high degree, is the experiment performed by Mr. Jesse. "I have often put," he says, "a small green caterpillar near an ant's nest; you may see it immediately seized by one of the ants, who, after several ineffectual efforts to drag it to its nest, will quit it, and go up to another ant, and they will appear to hold a conversation together by means of their antennæ, after which they will return together to the caterpillar, and, by their united efforts, drag it where they wish to deposit it."

Another fact in illustration of the same qualities is afforded by Kirby and Spence. "A German artist, a man of strict veracity, states that in his journey through Italy he was an eye-witness to the following occurrence. He observed a species of Scarabæus (*Ateuchus pilularius?*) busily engaged in making, for the reception of its egg, a pellet of dung, which when finished it rolled to the summit of a small

hillock, and repeatedly suffered to tumble down its side, apparently for the sake of consolidating it by the earth which each time adhered to it. During this process the pellet unluckily fell into an adjoining hole, out of which all the efforts of the beetle to extricate it were in vain. After several ineffectual trials, the insect repaired to an adjoining heap of dung, and soon returned with three of his companions. All four now applied their united strength to the pellet, and at length succeeded in pushing it out, which being done the three assistant beetles left the spot and returned to their own quarters."

That the bee makes a choice is seen in the perforation of a flower when she cannot or will not reach the nectary by walking into the corolla. The case observed by Mr. Bailey, already referred to on page 202, is in point. He observed humble bees which were baffled in their attempts to find the honey, take a short cut and perforate the corolla with their jaws. Here is an act of the will carried on under the stimulation of the organs of smell. Now as regards the act of choosing between two alternatives some bees are more intellectual than others, and the fact that there is a decided difference between two bees in this respect is additional proof that they have a reason.

In an article on the fertilization of various flowers by insects, in the "Popular Science Review," Dr. Ogle refers to this well known habit of both humble and hive bees of either perforating the flowers of the bean or getting at the honey by entering the mouth of the corolla. He noticed that while "some bees visit the blossom in the natural way, and in so doing take pollen from the anthers of one flower to the stigma of the next, others avail themselves of the shorter cut; but that an individual bee, visiting a succession of bean flowers, uniformly does one or the other. It would thus appear that the habit is not an instinct, belonging by inheritance to the whole species, but is in each case the result of

individual experience. As with the same experience some bees have acquired the habit and others have not, we must admit not only that these insects are intelligent, but that they differ from each other in their degrees of intelligence; some being slow in acquiring knowledge, others quicker. The scarlet runner, when the bloom is covered with gauze to keep off insects, is wholly sterile; and so indeed habitually are a good many of the uncovered blossoms. The latter is probably owing to the observed fact that most bees have learned to get at the nectary by nipping the tube. Were all bees equally clever there would be an end of scarlet runners, unless, indeed, either nature or artifice were to induce some modification of structure by which the tube might be protected and the bees again driven to the mouth."

The following instances are taken from Kirby and Spence, and are, we believe, the earliest cases of this habit on record.

"M. P. Huber, in his valuable paper in the sixth volume of the Linnean Transactions, states that he has seen large humble bees, when unable from the size of their head and thorax to reach the bottom of the long tubes of the flowers of beans, go directly to the calyx, pierce it as well as the tube with the exterior horny parts of their proboscis, and then insert their proboscis itself into the orifice and extract the honey. They thus flew from flower to flower, piercing the tubes from without, and sucking the nectar, while smaller humble bees or those with a longer proboscis entered in at the top of the corolla. Now from this statement it seems evident that the larger bees did not pierce the bottoms of the flowers until they had ascertained by trial that they could not reach the nectar from the top; but that having once ascertained by experience that the flowers of beans are too straight to admit them, they then, without further attempts in the ordinary way, pierced the bottoms of *all* the flowers which they wished to rifle of their sweets. M. Aubert du Petit-Thouars observed that humble bees and the carpenter-

bee (*Xylocopa violacea*) gained access in a similar manner to the nectar of *Antirrhinum Linaria* and *majus* and *Mirabilis Jalappa;* as do the common bees of the Isle of France to that of *Canna nidica;* and I have myself more than once noticed holes at the base of the long nectaries of *Aquilegia vulgaris*, which I attribute to the same agency."

Another instance of change of habit by the individuals of a species is afforded in the same work; we quote the following statement from Sturm. "It is the instinct of *Geotrupes vernalis* to roll up pellets of dung, in each of which it deposits one of its eggs; and in places where it meets with cow- or horse-dung only, it is constantly under the necessity of having recourse to this process. But in districts where sheep are kept, this beetle wisely saves its labor, and ingeniously avails itself of the pellet shaped balls ready made to its hands, which the excrement of these animals supplies."

Another instance where choice is made between two alternatives is stated by Mr. Darwin. In his "Origin of Species" he gives the following account. "One of the strongest instances of an animal apparently performing an action for the sole good of another, with which I am acquainted, is that of aphides voluntarily yielding, as was first observed by Huber, their sweet excretion to ants; that they do so voluntarily, the following facts show: I removed all the ants from a group of about a dozen aphides on a dock-plant, and prevented their attendance during several hours. After this interval, I felt sure that the aphides would want to excrete. I watched them for some time through a lens, but not one excreted; I then tickled and stroked them with a hair in the same manner, as well as I could, as the ants do with their antennæ; but not one excreted. Afterwards I allowed an ant to visit them, and it immediately seemed, by its eager way of running about, to be well aware what a rich flock it had discovered; it then began to play with its antennæ on

the abdomen first of one aphis and then of another; and each as soon as it felt the antennæ, immediately lifted up its abdomen and excreted a limpid drop of sweet juice, which was eagerly devoured by the ant. Even the quite young aphides behaved in this manner, showing that the action was instinctive, and not the result of experience. It is certain, from the observations of Huber, that the aphides show no dislike to the ants; if the latter be not present they are at last compelled to eject their excretion. But as the excretion is extremely viscid, it is no doubt a convenience to the aphides to have it removed; therefore probably they do not excrete solely for the good of the ants. Although there is no evidence that any animal performs an action for the exclusive good of another species, yet each tries to take advantage of the instincts of others, as each takes advantage of the weaker bodily structure of other species."

That there is much difference among individual ants, Dr. Linecum has affirmed in his article on the Agricultural Ant in the eighth volume of the "American Naturalist." "I have recently discovered," he says, "a great difference in their mental operations and capacities. Individuals there are which possess great intellectual superiority to the common laboring classes, which is manifested in the fact that they assume the leadership in all their important public works and army movements. Some are much more sagacious and cautious in avoiding traps and dangerous contrivances set for them by the scarcely superior human genus.

"One of our Germans invented a very destructive ant trap. It is set over the entrance to their city, and is so contrived that going or coming it is sure to entrap them; but not all of them. Occasionally a well formed fellow is observed to arrive at the top of the precipice, where he stops and gravely and cautiously surveys the awful abyss below, filled with frantic and terribly distressed thousands who have incautiously precipitated themselves into inevitable ruin, and after

viewing the dreadful and disastrous condition of his fellow laborers, he seems to understand the true nature of the misfortune, and turning from the irremediable calamity, hastens down the inclined plane into the grass weeds, beyond the reach of further observation. Quite a number of them were seen to examine and hastily fly from the entrance of this destructive trap."

That this story is not overdrawn is proved by a similar experience of Mr. J. D. Hague, of San Francisco, related in "Nature" (April 10, 1873). Being annoyed by thirty or forty ants on a shelf, he killed some and maimed others. "The effect of this was immediate and unexpected. As soon as those ants that were approaching arrived near to where their fellows lay dead and suffering, they turned and fled with all possible haste. In half an hour the wall above the mantelshelf was cleared of ants.

"During the space of an hour or two the colony from below continued to ascend, until reaching the lower beveled edge of the shelf, at which point the more timid individuals, although unable to see the vase, somehow became aware of trouble and turned about without further investigation; while the more daring advanced hesitatingly just to the upper edge of the shelf, where, extending their antennæ and stretching their necks, they seemed to peep cautiously over the edge until beholding their suffering companions, when they too turned and followed the others, expressing by their behavior great excitement and terror. An hour or two later the path or trail leading from the lower colony to the vase was almost entirely free from ants.

"I killed one or two ants on their path, striking them with my finger, but leaving no visible trace. The effect of this was that as soon as an ant ascending towards the shelf, reached the spot where one had been killed, it gave signs immediately of great disturbance, and returned directly at the highest speed possible.

"A curious and invariable feature of their behavior was that when such an ant, returning in fright, met another approaching, the two would always communicate, but each would pursue its own way; the second ant continuing its journey to the spot where the first had turned about, and then following that example.

"For several days after this there were no ants visible on the wall either above or below the shelf. Then a few ants from the lower colony began to reappear, but instead of visiting the vase which had been the scene of the disaster, they avoided it altogether, and following the lower front edge of the shelf to the tumbler standing near the middle, made their attack upon that. I repeated the same experiment here with precisely the same result. Killing or maiming a few of the ants, and leaving their bodies about the base of the tumbler, the others on approaching, and even before arriving at the upper surface of the shelf where their mutilated companions were visible, gave signs of intense emotion, some running away immediately and others advancing to where they could survey the field, and then hastening away precipitately.

"Occasionally an ant would advance towards the tumbler until it found itself among the dead and dying, then it seemed to lose all self-possession, running hither and thither, making wide circuits about the scene of the trouble, stopping at times and elevating the antennæ with a movement suggestive of wringing them in despair, and finally taking flight.

"After this another interval of several days passed, during which no ants appeared. Now, three months later, the lower colony has been entirely abandoned. Occasionally however, especially when fresh and fragrant violets have been placed on the shelf, a few 'prospectors' descend from the upper nail hole, rarely, almost never, approaching the vase from which they were first driven away, but seeking to satisfy their desire at the tumbler. To turn back these stragglers

and keep them out of sight for a number of days, sometimes for a fortnight, it is sufficient to kill one or two ants on the trail which they follow descending the wall. This I have recently done as high up as I can reach, three or four feet above the mantel. The moment this spot is reached an ant turns abruptly and makes for home; and in a little while there is not an ant visible on the wall."

Sir John Lubbock, who has studied the ways of ants, remarks that "it is wonderful how much individual ants appear to differ from one another in character."

Instinct is known in a few cases among insects, as well as other animals, to be variable. This is probably due to their power of discrimination, such as the higher animals undoubtedly possess. It has been asked, says Mr. Darwin, that if instinct be variable, "why the ability to use some other material when wax is deficient has not been granted to the bee?" "But," he answers, "what other material could bees use? They will work with and use, as I have seen, wax hardened with vermilion and softened with lard. Andrew Knight observed that his bees, instead of laboriously collecting propolis, used a cement of wax and turpentine, with which he had covered decorticated trees. It has lately been shown that bees, instead of searching flowers for their pollen, will gladly use a very different substance, namely, oatmeal." These instances seem to show that insects take the most advantageous means offered to them by nature for the accomplishment of their ends, that they individually exercise a choice, and that instinct varies in different individuals of a species. Within an exceedingly limited range insects exercise choice, and are free agents. They adapt themselves to new circumstances, and while there is perhaps little or no progress in the minds of individual animals, they somehow as a class keep pace with a changing, progressive world. No one will deny that creation has not been tending upwards, that higher forms of animal life have not on the

whole succeeded the lower. How could this have been brought about unless animals were provided with a variable instinct? Indeed, those who deny animals reason admit as an alternative that instinct is not always invariable. But how can instincts vary unless insects have in a slight degree the power of discrimination?

Mr. George H. Lewes, in an article on Instinct in "Nature" (April 10, 1873), has well summed up this subject of choice or discrimination in the following words: "To conclude: when there is no alternative open to an action it is impulsive; where there is, or originally was, an alternative, the action is instinctive; where there are alternatives which may still determine the action, and the choice is free, we call the action intelligent."

It follows that if insects do choose between two courses of action they have the power of perceiving the likeness between two objects. For example, a white butterfly has been seen to suddenly change its course and fly down to a piece of white paper. It perceives a similarity between the paper and one of its own species, or perhaps to a cruciferous flower on the leaves of which it lays its eggs. If it were not for this principle how could insects recognize others of their own species? It is obvious that insects have this principle of similarity strongly developed. Were it not for this mental quality the species would die out. By means of this power the bee recognizes its companions, and also by this power of identification or recognition, it finds its hive after leaving it out of sight for a long time. It is well known that bees and other insects may be lost. When they first begin to fly from the hive they go but a little distance and act as though fixing the landmarks in their mind. Making longer flights they familiarize themselves with the ground over which they fly, until, to those who have not known how this power of finding their way home has been attained, the act seems purely instinctive and not one of

individual education. Whether this is not the basis of the *migratory sense*, as we may call it, of birds is worth inquiry.

As an illustration of this power of recognition in the crabs, the next class below insects, the following statement of Mr. Robert Fox of Falmouth, England, is contributed by Mr. E. W. Cox to "Nature" (April 3, 1873). "The fishermen of Falmouth catch their crabs off the Lizard rocks, and they are brought into the harbour at Falmouth alive and impounded in a box for sale, and the shells are branded with marks by which every man knows his own fish. The place where the box is sunk is four miles from the entrance to the harbour, and that is above seven miles from the place where they are caught. One of these boxes was broken; the branded crabs escaped, and two or three days afterwards they were again caught by the fisherman at the Lizard rocks. They had been carried to Falmouth in a boat. To regain their home they had first to find their way to the mouth of the harbour, and when there, how did they know whether to steer to the right or to the left, and to travel seven miles to their native rocks?"

But bees could not find their way home from a distance of several miles, unless they possess *memory*, the third division of the intellect.

Unless insects possess memory, which consists in storing up in the mind, possibly through some change in the structure of the nervous system, the results of external impressions, we are at a loss to conceive how they can discriminate or perceive the points of resemblance between two objects after having been out of sight of them for a greater or less length of time. We are therefore, *a priori*, led to suppose that all insects have memory. Bain defines memory, acquisition or retention, as "being the power of continuing in the mind impressions that are no longer stimulated by the same agent, and of recalling them afterwards by purely mental forces." This definition will hold in insect as well as human

psychology. How a bee can return to its hive from afar unless it remembers the way back we cannot understand. It does not explain the fact to say that it is instinctive or due to some impulse. The impulse is present, but it simply urges the insect to start on the road; memory aided by discrimination and the sense of similarity show the bee how to perform the journey, and select its own hive from among the others near it.

We may, with Kirby and Spence, not believe that the bee is guided home by varied scents, but in Rogers' fine lines can exclaim:

> "Who guides the patient pilgrim to her cell?
> Who bids her soul with conscious triumph swell?
> With conscious truth retrace the mazy clue
> Of varied scents that charm'd her as she flew?
> Hail, *Memory*, hail! thy universal reign
> Guards the least link of Being's glorious chain."

No automaton could find its way back to a point from which it had once started, however well the machine had been originally wound up. Nor does the common notion of an inflexible instinct meet the case! Memory is often due to a repetition of certain experiences, and experiences lay the foundation for instinctive acts; it is the sum of these inherited experiences which make up the total which passes under the name of instinct.

That bees, previous to flying away for long distances, observe closely the surrounding objects which serve as land marks or guide-posts, seems proved by the statement of Huber, that "if a hive be removed out of its ordinary position, the first day after this removal the bees do not fly to a distance without having visited all the neighboring objects. The queen does the same when flying into the air for fecundation." Does not the bee act in the same manner as we would do on leaving for the first time a hotel in a strange city? We mentally construct a topographical map as we walk away from the house, in order to readily find our way

back. Are not the mental processes the same in kind, however different in degree?

"But," says our author, from whom we have borrowed the suggestions just made, "the most striking fact evincing the memory of these last mentioned insects has been communicated to me by my intelligent friend, Mr. William Stickney, of Ridgemont, Holderness. About twenty years ago a swarm from one of this gentleman's hives took possession of an opening beneath the tiles of his house, whence, after remaining a few hours, they were dislodged and hived. For many subsequent years, when the hives descended from this stock were about to swarm, a considerable party of scouts were observed for a few days before to be reconnoitring about the old hole under the tiles, and Mr. Stickney is persuaded, that if suffered they would have established themselves there. He is certain that for eight years successively the descendants of the very stock that first took possession of the hole frequented it as above stated, and *not* those of any other swarms; having constantly noticed them, and ascertained that they were bees from the original hive by powdering them while about the tiles with yellow ochre, and watching their return. And even at the present time, there are still seen every swarming season about the tiles, bees, which Mr. Stickney has no doubt are descendants from the original stock.

"Had Dr. Darwin* been acquainted with this fact, he would have adduced it as proving that insects can convey traditionary information from one generation to another; and at the first glance the circumstance of the descendants of the same stock retaining a knowledge of the same fact for twenty years, during which period there must have been as many generations of bees, would seem to warrant the inference. But as it is more probable that the party of survey-

* Dr. Erasmus Darwin, the grandfather of the author of the "Origin of Species."

ing scouts of the first generation was the next year accompanied by others of a second, who in like manner conducted their brethren of the third, and these last again others of the fourth generation, and so on, I draw no other conclusion from it than that bees are endowed with memory, which I think it proves most satisfactorily."

The daily acts of a bee are quite complicated, if we take into account all the journeys it makes, the pollen and honey it collects, the complicated process of loading itself with the mass, which it collects with its tongue, rearranges by means of its jaws, transfers from the fore to the hind feet, and piles up on its shallow honey-basket. Then think of the far more difficult operations that it carries on within the hive. How are the impressions gained in its first day's flight preserved, and not only this but transmitted to its descendants? I am now speaking of the queen humble bee or wasp. The only theory that seems to account satisfactorily for these acts is the physical theory of some physiologists, as Beale, that every mental act is accompanied by a change in the cells of the nerve centres. This is largely a matter of speculation and must be regarded as such. Professor Bain has from the facts afforded by Beale been led to make a hypothetical comparison between, as he says, "these two things, our acquisitions on the one hand, and the nervous elements of the brain on the other." He supposes that "with a total of 200,000 acquisitions of the assumed types, which would certainly include the most retentive and most richly-endowed minds, there would be for each nervous grouping 5000 cells and 25,000 fibres." Now this is hypothesis, mere guess work, as the author avows, but based on anatomical facts. Using this hypothesis simply for the purpose of illustration, if these figures represent in a rude and meagre way the number of cells and acquisitions in the brain and mind of man, how exceedingly small must be the number of cells and acquisitions in a bee's brain and mind. We know from

anatomical investigations that the number of nerve cells in the small ganglia of the bee must be very small, perhaps a few hundreds at the most; on this hypothesis the number of acquisitions must be correspondingly small. Now there is not the differences between the brains of insects that there is in vertebrate animals. There is a great uniformity in the size of the nerve centres of different insects, and on anatomical grounds there would seem to be a reason for asserting that insects can never progress in intellect much beyond their present status. We are only endeavoring to prove that insects have the primary intellectual divisions of the human mind, but the chasm that still separates man from the lower animals is vast in its width and depth. If we approach the subject from the side of anatomy and physiology the method is far less materialistic than that of him who advocates the view that animals are automata and act through instinct alone.

Having attempted to show that insects have a mind, in its three-fold divisions of the sensibilities, will and intellect, and supported in this view by the opinions of the ablest naturalists and philosophers, let us look at some secondary mental characteristics resulting from the mutual operation of all these primary departments of the mind, and which insects seem to have in common with ourselves.

From some facts previously stated, it seems well established that ants and a few other insects have the highly complicated mental power of communicating their ideas to one another. Dr. Franklin believed that ants had this power, and to put the matter to a test he put a little earthen pot, containing some treacle, into a closet, where a number of ants soon congregated, and began to prey on the contents. "When it was all eaten the Doctor cleared the pot of the ants, and putting some fresh treacle into it, suspended it by a string from a nail in the ceiling. By chance a single ant remained in the pot, which ate as long as it thought proper;

but when it wanted to get away, it could not for some time find the means. It ran about the outside of the pot in perplexity; but at last it found the way up the string to the ceiling, along which it ran to the wall, and so to the ground. It had scarcely been half an hour gone, when a numerous swarm of ants came into the closet, climbed up the wall to the ceiling, and then descended by the string into the pot. There they continued to eat till the treacle was all devoured, each taking his departure when he was satisfied, and one party running up the string and the other down." (Watson's Reasoning Power in Animals.)

There are other anecdotes on record more or less founded on observation and experiment which confirm the prevalent idea regarding this complicated mental process. Sir John Lubbock has called in question in his "Observations on Bees and Wasps" the statements made by other observers that bees and wasps have this faculty. He made a number of experiments which "in opposition to the statements of Huber and Dujardin, seem to show that wasps and bees do not convey to one another information as to food which they may have discovered." This does not necessarily oppose the view that these insects may communicate to one another the presence of danger. In a later communication to the Linnæan Society of London, as reported in "Nature," but not yet published in full, Lubbock has recorded a number of experiments on ants, "which certainly seemed to show that, whatever may be the case with bees, ants do possess the power of communicating detailed facts to one another." How insects can exist in colonies without this power is a pertinent question.

That individual insects undergo a process of education seems to be established from the fact that the social bees can be domesticated. The honey bee is the only domestic insect we have. Besides the *Apis mellifica*, the *Apis dorsata*, *A. indica* and *A. nigrocincta*, of India, and the *Apis fasci-*

ata of Egypt are domesticated in those countries, and there are two or three other species not domesticated, whose honey and wax are used by the natives of the countries they inhabit. The *Melipona domestica* is said by Huber to be, as its specific name indicates, domesticated by the Mexicans. Huber, in his entertaining paper, figures a long cylindrical clay nest which the natives of Tepic keep hanging up in their houses; some of these nests are known to be over a century old, so that it seems probable that the bees have for several centuries been in a state of domestication.

Another trait of much interest which seems to result from its social life is, that the honey bee ventilates its hive by fanning its wings. This may be regarded as a simply instinctive process, but it appears to us an unusual act, and one resulting from some degree of ratiocination.

Many animals are excellent mimics, and it is a question whether the faculty of imitation is not very well developed in social insects. Indeed, were it not for this trait, how could ants and bees act with that unanimity of purpose which distinguishes their insect republics, and which is the chief bond of action among them? Were it not for this principle the life of the colony and of the species would soon come to an end.

After having in an imperfect manner gone over some of the obvious mental traits of the insects, and which seem to our apprehension to be only properly classified as reasoning processes, the question arises whether in performing some of the more unusual feats of mental strength, such, for example, as communicating their ideas to one another, they may not have a dim consciousness of what they are doing. To talk of communicating their *ideas*, without some degree of consciousness during the act would seem illogical. Whether insects are wholly dominated by an unconscious intelligence I leave for others better qualified than myself to judge; meanwhile one in view of known psychological facts cannot

help suspecting that at times, even insects know what they are doing while performing extraordinary, superinstinctive acts.

Locke and Dugald Stewart, says Brodie in his "Mind and Matter," do not allow that "brute animals have the power of abstraction. Now taking it for granted that abstraction can mean nothing more than the power of comparing our conceptions with reference to certain points to the exclusion of others; as, for example, when we consider color without reference to figure, or figure without reference to color; then I do not see how we can deny the existence of this faculty in other animals any more than in man himself. In this sense of the word, abstraction is a necessary part of the process of reasoning, which Locke defines as being 'the perception of the agreement or disagreement of our ideas.'" Brodie then observes that Dugald Stewart does not mean to deny that brute animals are capable of the simpler forms of reasoning. Watson says that Locke "was not unwilling to allow beasts a portion of reason, for though, he says, they have no power of abstraction, or use of language, to increase their ideas, yet, if they are not mere machines, we cannot deny them to have some reason, and for his own part, he adds, 'it seems as evident that they do some of them in certain cases reason, as that they have sense.'"

Now all that has been said regarding the intelligence of insects, serves simply to pave the way for a consideration of the nature of instinct. While engaged in collecting the material for this chapter and putting it in form, this thought has often recurred; if insects have sufficient intelligence to meet the extraordinary emergencies of their lives, why may not their every day, their so-called instinctive acts, requiring a minimum of intellectual work, have originated in previous generations, and thus the instincts of the present generation be the sum total of the inherited mental experiences of former generations? Indeed, can there be any other rational

explanation of that complex of mental processes we call instinct?

Insects in the first place act from impulse, urged on by their appetites; thus far they are unconscious automata. These automatic actions are due probably to reflex nervous acts and to the stimulation of their reproductive and other animal appetites upon meeting with the objects of their desires. These reflex actions of the nervous ganglia are essential for the maintenance of the life of the individual and of the species. They do not come properly under the head of purely instinctive acts. There are a great many acts however, to which the term instinctive will apply. As an example to show how many different instinctive acts may be performed by the individuals of a single species, I will avail myself of the enumerations made by Kirby and Spence, occasionally condensing his language. Beginning, then, with the formation of the colony. "By one instinct bees are directed to send out scouts previously to their swarming, in search of a suitable abode; and by another to rush out of the hive after the queen that leads forth the swarm, and follow wherever she bends her course. Having taken possession of their new abode, whether of their own selection or prepared for them by the hand of man, a third instinct teaches them to cleanse it from all impurities; a fourth to collect propolis, and with it to stop up every crevice except the entrance; a fifth to ventilate the hive for preserving the purity of the air; and a sixth to keep a constant guard at the door.

"In constructing the houses and streets of their new city, or the cells and combs, there are probably several distinct instincts exercised; but not to leave room for objection, I shall regard them as the result of one only; yet the operations of polishing the interior of the cells, and soldering their angles and orifices with propolis, which are sometimes not undertaken for weeks after the cells are built; and the

obscure but still more curious one of varnishing them with the yellow tinge observable in old combs;—seem clearly referable to at least two distinct instincts.

"In their out-of-door operations, several distinct instincts are concerned. By one they are led to extract honey from the nectaries of flowers, by another to collect pollen after a process involving very complicated manipulations, and requiring a singular apparatus of brushes and baskets; and that must surely be considered a third, which so remarkably and beneficially restricts each gathering to the same plant. It is clearly a distinct instinct which inspires bees with such a dread of rain, that even if a cloud pass before the sun, they return to the hive in the greatest haste; and that seems to me not less so, which teaches them to find their way back to their home after the most distant and intricate wanderings.

"When they have reached the hive, another instinct leads them to regurgitate into the extended proboscis of their hungry companions who have been occupied at home, a portion of the honey collected in the fields; and another directs them to unload their legs of the masses of pollen, and to store it in the cells for future use.

"Several distinct instincts, again, are called into action in the important business of feeding the young brood. One teaches them to swallow pollen, not to satisfy the calls of hunger, but that it may undergo in their stomach an elaboration fitting it for the food of the grubs; and another to regurgitate it when duly concocted, and to administer it to their charge, proportioning the supply to the age and condition of the recipients; a third informs them when the young grubs have attained their full growth, and directs them to cover their cells with a waxen lid, convex in the male cells, but nearly flat in those of the workers; and by a fourth, as soon as the young bees have burst into day, they are impelled to clean out the deserted tenements and to make them ready for new occupants.

"Numerous as are the instincts I have already enumerated, the list must yet include those connected with that mysterious principle which binds the working bees of a hive to their queen—the singular imprisonment in which they retain the young queens that are to lead off a swarm, until their wings be sufficiently expanded to enable them to fly the moment they are at liberty, gradually paring away the waxen wall that confines them to their cell to an extreme thinness, and only suffering it to be broken down at the precise moment required; the attention with which, in these circumstances, they feed the imprisoned queen by frequently putting honey upon her proboscis, protruded from a small orifice in the lid of her cell; the watchfulness with which, when at the period of swarming more queens than one are required, they place a guard over the cells of those undisclosed, to preserve them from the jealous fury of their excluded rivals; the exquisite calculation with which they invariably release the *oldest* queens the first from their confinement; the singular love of monarchical dominion, by which, when two queens in other circumstances are produced, they are led to impel them to combat until one is destroyed; the ardent devotion which binds them to the fate and fortunes of the survivor; the distraction which they manifest at her loss, and their resolute determination not to accept of any stranger until an interval has elapsed sufficiently long to allow of no chance of the return of the rightful sovereign; and (to omit a further enumeration) the obedience which in the utmost noise and confusion they show to her well-known hum.

"I have now instanced at least thirty distinct instincts with which every individual of the nurses amongst the working-bees is endowed; and if to the account be added their care to carry from the hive the dead bodies of any of the community; their pertinacity in their battles, in directing their stings at those parts only of the bodies of their adversaries which are penetrable by it; their annual autumnal murder

of the drones, etc., etc., it is certain that this number might be very considerably increased, perhaps doubled."

Most, though perhaps not all, of these acts are as purely instinctive as any one can imagine; all bees do them in nearly the same manner, and as readily the moment they leave their cells as a few days or weeks after. Such acts may be called automatic, though not so much so as the process of walking, flying, running and biting their prey. They may be accomplished by the reflex action of the nerve centres in the insects of the present generation, though in the beginning secondarily reflexive.

As regards the ordinary instinctive acts one may quite agree with Descartes that insects are automata. But the matter does not rest here. There is a history we believe yet to be written, in the light of facts which remain to be discovered by patient observation, of the origin of animal instincts, and which will tend to prove that instincts may be regarded, in most cases at least, as the sum of inherited experiences.

Lamarck believed that instincts were due to certain inherent inclinations arising from habits impressed upon the organs of the animals concerned in producing them. Mr. Darwin combats Lamarck's view which he calls "the well known doctrine of inherited habit, as advanced by Lamarck." Rev. J. J. Murphy in his "Habit and Intelligence" leads us to infer that he regards instinct as the sum of inherited habits. He well remarks, and this is the sum of the whole matter: "reason differs from instinct only in being conscious. Instinct is unconscious reason, and reason is conscious instinct." This is tantamount to saying that the instinct of the present generation of insects is unconscious automatism, but that their ancestors who first learned by experience how to build, for example, hexagonal cells, were taught by reason, were conscious, intelligent agents; and this is where we would leave the subject.

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